Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation

Consultation on the "Willamette River Basin Flood Control Project"

Action Agencies:	U.S. Army Corps of Engineers Bonneville Power Administration U.S. Bureau of Reclamation
Consultation Conducted by:	NOAA's National Marine Fisheries Service (NMFS) Northwest Region
NOAA Fisheries Log Number:	F/NWR/2000/02117
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Issued by:	D. Robert Lohn Regional Administrator

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ACRONYMS & ABBREVIATIONS

Action Agencies	USACE, BPA, and Reclamation
AM	annual milestones
AFS	American Fisheries Society
APA	Administrative Procedure Act
BA	Biological Assessment submitted by the Action Agencies to NMFS and USFWS on April 26, 2000
BIA	Bureau of Indian Affairs
BKD	bacterial kidney disease
BLM	U.S. Bureau of Land Management
BMP	best management practice
BPA	Bonneville Power Administration
BRT	Biological Review Team
CAP	Continuing Authorities Program
CBFWA	Columbia River Basin Fish & Wildlife Authority
cfs	cubic feet per second
CHARTS	Critical Habitat Analytical Review Teams
COP	configuration/operation planning
CPEC	Construction Projects Environmental Coordinating Committee
CR	Columbia River
CRFM	Columbia River Fish Mitigation
CRHRP	Columbia River Hatchery Reform Project
CRITFC	Columbia River Inter-Tribal Fish Commission
CSOs	combined sewer overflows
CTGR	Confederated Tribes of the Grand Ronde Community of Oregon
CTSI	Confederated Tribes of the Siletz Indians
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWS	Confederated Tribes of the Warm Springs Reservation
CWA	Clean Water Act
CWC	Calapooia Watershed Council
CWTs	Coded wire tags
DC	direct current
DDR	detailed design report
Defendants	NMFS, USFWS, USACE, and Reclamation
DEQ	Oregon Department of Environmental Quality
DO	Dissolved Oxygen
DPS	distinct population segment

DQA	Data Quality Act
ECC	Environmental Coordinating Committee
EFH	essential fish habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
EWEB	Eugene Water & Electric Board
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FL	fork length
FM	Flow Management Committee
FMEP	Fisheries Management & Evaluation Plan
FPHM	Fish Passage and Hatchery Management Committee
FPMP	Fish Passage and Management Plan
fps	feet per second
GBT	gas bubble trauma
GI	General investigations
gpm	gallons per minute
HD	House Document
HGMP	Hatchery Genetic Management Plan
HSRG	Hatchery Scientific Review Group
HUC	Hydrologic Unit Code
HUC5	Hydrological Unit Code (at the fifth field scale, for example)
ICTRT	Interior Columbia TRT
IHN	Infectious Hematopoietic Necrosis
IHOT	Integrated Hatchery Operations Team
IM	interim milestones
ISAB	Independent Science Advisory Board
IT	incidental take
ITS	Incidental take statement
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LGMSC	Lower Granite Migration Study Steering Committee
LTWC	Long Tom Watershed Council
LWD	large woody debris
MAF	millions of acre feet
MCR	Middle Columbia River
MHHW	mean higher high waters
MM	major milestone

MPG	major population groups
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MW	megawatts
NCBC	North Coast British Columbia
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPPC	Northwest Power Planning Council
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NTP	natural thermal potential
NTU	Nephelometric Turbidity Units
O&M	operations and maintenance
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OFC	Ocean Fish Commission
Opinion	this Biological Opinion
OPRD	Oregon Parks & Recreation Department
OWQI	Oregon Water Quality Index
OWRD	Oregon Water Resources Department
PA	Proposed Action
PAC	post-authorization change
PAH	Polynuclear aromatic hydrocarbons
PAS	Planning Assistance to States
PCE	primary constituent element
PDO	Pacific decadal oscillation
PFMC	Pacific Fishery Management Program
PGE	Portland General Electric Company
PIT-tag	Passive integrated transponder – tag
Plaintiffs	Willamette Riverkeepers and Northwest Environmental Defense Center
PNERC	Pacific Northwest Ecosystem Research Consortium
PNI	proportion of natural influence
PST	Pacific Salmon Treaty
RCC	USACE Northwest Division’s Reservoir Control Center
Reclamation	U.S. Bureau of Reclamation
RER	Rebuilding Exploitation Rate

RM	River mile
RM&E	research, monitoring, and evaluation
RO	regulating outlet
RPA	reasonable and prudent alternative
RPM	reasonable and prudent measure
RSW	removable spillway weirs
SCAB	Steelhead and Chinook above Barriers Committee
SEAK	Southeast Alaska
Services	NMFS and USFWS, collectively
SIWG	Species Interaction Work Group
SLOPES	Standard Local Operating Procedures for Endangered Species
SOI	Southern Oscillation Index
SOP	standard operating procedure
SR	Snake River
SRP	Sustainable Rivers Project
STEP	Salmon and Trout Enhancement Project
Supplemental BA	Supplemental Biological Assessment submitted by the Action Agencies to NMFS and USFWS on May 31, 2007
SWCD	Santiam Water Control District
T&C	terms and conditions
TDG	total dissolved gas
TL	total length
TMDL	total maximum daily load
TNC	The Nature Conservancy
TRT	technical recovery team
TU	temperature unit
UCR	Upper Columbia River
UNREG	unregulated conditions
USACE	U.S. Army Corps of Engineers
USBR	US Bureau of Reclamation
USDA	US Department of Agriculture
USDI	US Department of Interior
USEPA	US Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWR	Upper Willamette River
VSP	viable salmonid populations
WLCTRT	Willamette/Lower Columbia Technical Recovery Team

WATER	Willamette Action Team for Ecosystem Restoration
WCP	Willamette Conservation Plan
WCSBRT	West Coast Salmon Biological Review Team
WFOP	Willamette Fish Operations Plan
WNF LRD	Willamette National Forest Lowell Ranger District
WNF	Willamette National Forest
WQMP	Water Quality Management Plan
WQTC	Water Quality and Temperature Control Committee
WRDA	Water Resources Development Act of 1950
WRI	Willamette Restoration Initiative
WTC	water temperature control
Yakama	Yakama Indian Nation

Chapter 1
Introduction

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1 INTRODUCTION

1.1 OBJECTIVES

This Biological Opinion (Opinion) is the result of an interagency consultation under Section 7(a)(2) of the Endangered Species Act (ESA) on the effects of the configuration, operations, and maintenance of the Willamette Valley Project (Willamette Project) on 13 listed species of Pacific salmon and steelhead, North American green sturgeon of the Southern DPS, and Southern Resident killer whale DPS. There are three Federal Action Agencies in this consultation because each plays a role in the Willamette Project. The U.S. Army Corps of Engineers (USACE) operates and maintains the 13 multipurpose dams and maintains about 43 miles of revetments in the upper Willamette basin; Bonneville Power Administration (BPA) markets power generated at some of the Willamette Project dams; and the U.S. Bureau of Reclamation (Reclamation) sells a portion of the water stored in Project reservoirs for irrigation purposes.

The National Marine Fisheries Service (NMFS) is responsible for administration of the ESA with respect to anadromous salmonids, green sturgeon, and killer whales. Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions do not jeopardize the continued existence of listed species or adversely modify designated critical habitat. To "jeopardize the continued existence of" means to engage in an action that reasonably is expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild, by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

The Action Agencies submitted a Biological Assessment (BA) (USACE 2000) to NMFS and U.S. Fish and Wildlife Service (USFWS, and collectively with NMFS, the Services) on April 26, 2000, and a Supplemental Biological Assessment (Supplemental BA) (USACE 2007a) on May 31, 2007, requesting consultation on the effects of the Willamette Project on species listed as threatened or endangered under the ESA, and on their critical habitat. The Action Agencies' Proposed Action consists of the continued operation and maintenance of the Willamette Project, which provides flood control, hydropower generation, water quality, water for irrigation, and other project purposes, including fisheries conservation and recreation. As part of the Proposed Action, the Action Agencies propose to reduce adverse effects on ESA-listed species by releasing minimum flows and reducing Project ramping in tributaries below dams; maintaining minimum flows in the mainstem Willamette River; constructing, operating, and maintaining fish collection and passage facilities at priority sites above and below Project dams; operating, improving, and maintaining Project hatcheries; and carrying out a series of research, monitoring, and evaluation actions to assess the effectiveness of the mitigation measures. The Proposed Action is described in more detail in Section 2 of this document and in the Action Agencies' BA (USACE 2000) and Supplemental BA (USACE 2007a), which are incorporated herein by reference as the complete version of the proposed action for this consultation.

The objectives of this Opinion are: (1) to determine the effects of the Proposed Action on 13 salmon evolutionarily significant units (ESUs) and steelhead distinct population segment (DPS), as well as the Southern DPS of North American green sturgeon (*Acipenser medirostris*), and Southern Resident killer whales (*Orcinus orca*), and (2) to determine if the Proposed Action is likely to jeopardize the continued existence of these ESA-listed species under NMFS' jurisdiction, or adversely modify or destroy designated critical habitat for these species. Because there are multiple ESA-listed species are affected by the proposed action, and some of these are under USFWS jurisdiction, the Action Agencies consulted jointly with the Services. However, USFWS and NMFS wrote separate Biological Opinions.

This Opinion and the incidental take statement were prepared by NMFS in accordance with the ESA of 1973 (16 USC 1531 et seq.) and implementing regulations at 50 CFR 402. The analyses in this Opinion are based on NMFS' review of the best available scientific and commercial information. In this Opinion, NMFS concludes that the Proposed Action is likely to jeopardize the continued existence of Upper Willamette River (UWR) Chinook salmon and UWR steelhead, and to adversely modify or destroy designated critical habitat for these species. NMFS also concludes that the Proposed Action is likely to adversely affect, but not likely to jeopardize, the continued existence of the other 11 species of Interior and Lower Columbia Basin salmon and steelhead. Additionally, NMFS concludes that the Proposed Action is not likely to adversely modify or destroy designated critical habitat for the ten Interior and Lower Columbia Basin species for which it has been designated. Because the conclusion of this Opinion is that the Proposed Action jeopardizes two of the listed species of salmon and steelhead under NMFS' authority, NMFS developed and provides a reasonable and prudent alternative (RPA) to ensure their survival with an adequate potential for recovery. NMFS determines that the RPA and Proposed Action combined are not likely to adversely affect the Southern Resident killer whale DPS or the Southern DPS of North American green sturgeon, or to destroy or adversely modify critical habitat designated for the Southern Resident killer whale.

NMFS is also responsible for consultations conducted under Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) regarding essential fish habitat (EFH) consultation requirements. Section 305(b)(2) of the MSA requires Federal agencies to consult with NMFS if their actions may adversely affect EFH. Added to this Opinion is NMFS' assessment of whether the Proposed Action may result in adverse effects on EFH, and EFH conservation recommendations provided under Section 305(b)(4) of the MSA. NMFS prepared the EFH consultation in accordance with Section 305(b) of the MSA (16 USC 1855(b)) and implementing regulations at 50 CFR 600 subpart K.

The administrative records for both the ESA and MSA consultations are on file at NMFS' Northwest Regional Office in Portland, Oregon.

1.2 Consultation Procedural History

1.2.1 ESA Consultation on Willamette Project Operations

Discussions between the USACE, USFWS, and NMFS on the ESA Section 7(a)(2) consultation requirements for the Willamette Project began in early 1999, shortly before UWR Chinook salmon *(Oncorhychus tshawytscha)* and UWR steelhead *(O. mykiss)* were listed (on March 24 and March 25, 1999, respectively [NMFS 1999a and 1999b]). A letter from USFWS to the USACE, dated February 9, 1999, outlined the issues that these two agencies had agreed should be covered in a single BA for a Section 7(a)(2) consultation. A letter from NMFS to the

USACE, dated February 25, 1999, provided additional guidance concerning the types of information to be included in the BA for UWR Chinook salmon and UWR steelhead.

On March 26, 1999, USACE sent a letter to NMFS requesting a species list for the Willamette Basin, which NMFS provided on March 30, 1999. Over the next year, the Services worked closely with USACE and its contractor to develop the BA for the Willamette Project. The Services and the USACE, in collaboration with the State of Oregon, also developed an approach to spring and early summer flow management that could be implemented while consultation was underway (ODFW 2000).

In April 2000, the USACE transmitted the 2000 BA (USACE 2000) to the Services and requested initiation of ESA Section 7 consultation on the impacts of the Willamette Project and maintenance of 43 miles of revetments on ESA-listed species. The proposed action contained in the 2000 BA was based on operation of the Willamette Project prior to the ESA-listing of UWR Chinook salmon and UWR steelhead in 1999. The 2000 BA concluded that the proposed action was “likely to adversely affect” several fish species and one plant species. On the basis of this finding, the USACE requested formal consultation with the Services. The BPA and Reclamation joined the USACE as Action Agencies for this Section 7 consultation at this time.

The Services provided a preliminary Federal review draft of a joint Biological Opinion to the Action Agencies on September 22, 2000. The analysis in the draft Opinion concluded that the continued operation of the Willamette Project was likely to jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and was likely to adversely modify designated critical habitat for the two species. When the draft was released, the USFWS had not completed its analysis of the Project’s effects on bull trout, thus a jeopardy/non-jeopardy conclusion for that species was not included. Because the draft Opinion concluded jeopardy for two species, it included a draft RPA to avoid jeopardy. The Action Agencies developed a set of combined comments on the Federal review draft, which the Services received on January 12, 2001.

On March 22, 2001, the Services provided a revised draft of the RPA to the Action Agencies. The Action Agencies responded with a consolidated set of comments on April 25, 2001. The Services and the Action Agencies met frequently throughout the summer and fall of 2001 to revise and refine the RPA.

By letter dated May 24, 2002, the Action Agencies submitted an amendment to the 2000 BA (USACE 2000) proposing to increase the volume of stored water that could be released from Project dams to accommodate new Reclamation water service contracts. The USACE proposed to add an additional 10,000 acre-feet to the total amount of storage immediately available for water service contracts, for a total of 95,000 acre-feet. The USACE determined that the amended action would result in insignificant incremental effects on listed species, and that the existing BA adequately described the effects of the action on listed species. NMFS replied on August 7, 2002, that it would adjust the scope of the ESA consultation to include this amendment to the water service contracting program, and advised Reclamation to ensure that any actions taken prior to issuance of the Opinion be taken in a manner consistent with section 7(d) of the ESA. Reclamation replied to the Services by letter, dated January 10, 2003, confirming its decision to resume full contracting activities for irrigation water service from the Willamette

Project. Reclamation stated that it would proceed to review, approve, and execute short-term contracts in a manner consistent with section 7(d) of the ESA.

In October 2002, the Services, USACE, BPA, and Reclamation formed a senior-level policy group, called the Managers' Forum, to address Willamette Project issues. This group met approximately monthly through the winter of 2003 to review the progress of the consultation, and to discuss and resolve outstanding issues.

Although the Services initially intended to prepare a single, jointly written Biological Opinion for the Willamette Project, the size and complexity of the consultation ultimately argued against this approach. The Services decided in February 2003, to write two separate Biological Opinions. Despite this change, the Services have still considered this to be a joint consultation, and continued to coordinate between themselves.

By letter dated July 25, 2003, NMFS submitted a revised draft jeopardy Opinion, Chapters 1 through 8, to the Action Agencies for review and comment. On April 26, 2004, NMFS provided a preliminary revised draft RPA. On December 28, 2004, the Action Agencies provided consolidated comments on the NMFS revised draft Opinion, Chapters 1 through 8, identifying a number of key areas of concern that the Action Agencies believed should be resolved before completing consultation.

1.2.2 ESA Consultation on Willamette Project Hatcheries

On March 29, 2000, the USACE and BPA requested initiation of Section 7(a)(2) consultation on the impacts of the artificial propagation programs in the Willamette Basin on listed UWR Chinook salmon and UWR steelhead. On July 14, 2000, NMFS issued a *Biological Opinion on the Impacts from Collection, Rearing, and Release of Salmonids Associated with Artificial Propagation Programs in the Upper Willamette Spring Chinook and Winter Steelhead Evolutionarily Significant Units* (NMFS 2000a; hereinafter called the 2000 Hatchery Opinion), which provided an incidental take statement (ITS) to the USACE and BPA for operation of the hatchery mitigation programs in the Willamette Basin through September 30, 2003. Since expiration of the 2000 Hatchery Opinion, the Action Agencies worked with NMFS to put in place a new biological opinion, as described below.

1.2.3 Merging Hatcheries & Project Operations into a Single Consultation, Development of the 2007 Supplemental BA, and Completion of the NMFS Opinion

On January 3, 2006, the USACE notified the Services of the Action Agencies' decision to prepare a revised proposed action and supplement the 2000 BA. The Action Agencies proposed that the hatchery and Willamette Project consultations be merged because they had many related and overlapping actions. The revised proposed action integrated hatchery operations and recommendations for hatchery reform described in the Oregon Department of Fish and Wildlife's (ODFW) Hatchery Genetic Management Plans (HGMPs). Also, it incorporated measures to be consistent with NMFS' Hatchery Listing Policy (NMFS 2005a), which clarifies that any hatchery-origin population that is part of the same ESU or DPS as a listed natural-origin population must also be listed under ESA. The Action Agencies proposed to include in the Supplemental BA certain structural measures they had the authority to implement, such as replacing hatchery fish collection facilities located at the base of some of the dams, which were not originally equipped to handle ESA-listed fish. In addition to hatchery operations, the Action Agencies decided to revise the proposed action for the Willamette Project to more accurately reflect current operations, particularly the mainstem and tributary flow modifications implemented since 1999, and to address other issues that came up since 2000.

Throughout 2006 and early 2007, the Action Agencies and Services met regularly to clarify and add detail to measures that would be included in the revised proposed action. The Action Agencies issued the Supplemental BA (USACE 2007a) on May 31, 2007.

On July 17, 2007, NMFS submitted a letter to the Action Agencies requesting additional information on actions proposed in the Supplemental BA. While the Action Agencies were preparing additional analyses in response to NMFS' request, NMFS organized a series of technical and senior policy meetings to clarify outstanding issues. These meetings with the Action Agencies and USFWS, which were facilitated, took place from September 2007 through January 2008 and culminated in general agreement on the terms of a RPA.

During the period, October 2007 through June 2008, the Action Agencies provided the following additional information to NMFS to assist in completion of this Opinion:

- October 2, 2007 letter from the USACE to NMFS, providing reference material and Project operations' modeling results;
- December 14, 2007 letter from USACE to NMFS, identifying specific fish passage and water quality measures that had been agreed to in the 2007 facilitated meetings;
- January 30, 2008 letter from USACE to NMFS, clarifying the measures identified in the December 14, 2007 letter;
- June 2, 2008 email from Alan Donner, USACE, to NMFS, providing additional Project operational and flow modeling analyses in response to NMFS' request; and
- June 17, 2008 letter from USACE, on behalf of the Action Agencies, to NMFS, providing analyses of the effects of the revised proposed action on North American green sturgeon and Southern Resident killer whale, and an analysis of effects of the proposed action taking into consideration climate change. The Action Agencies also requested EFH consultation with NMFS, as required by the MSA.

From January through April, 2008, NMFS was revising its earlier draft Opinion to evaluate the revised proposed action described in the Supplemental BA (USACE 2007a), as well as the subsequently provided additional information, as described in the previous paragraph, and the draft RPA. During this same period, NMFS participated in two staff-level meetings with Oregon Water Resources Department (OWRD), Reclamation, BPA, and USACE to seek clarification on possible mechanisms to protect flows released from Project reservoirs for fish purposes from out-of-stream diversion by holders of Oregon water rights for natural flows. In this Opinion, NMFS includes an RPA measure that requires the Action Agencies to take actions and provide information to OWRD to assist in the process of protecting flows for fish purposes.

NMFS issued a draft Opinion on April 30, 2008 for review by the Action Agencies. In addition to written comments from the Action Agencies, NMFS received verbal comments at 4 days of meetings held with them and USFWS in early May, 2008. NMFS considered Action Agencies' comments, as well as verbal comments received from several Tribes (see section 1.3 below regarding consultation with affected Tribes), in the preparation of this final Opinion, issued July 11, 2008.

1.2.4 Litigation & Settlement

On September 20, 2007, Willamette Riverkeepers and Northwest Environmental Defense Center (plaintiffs) filed a complaint in the United States District Court for the District of Oregon, against NMFS, USFWS, USACE and Reclamation (defendants) alleging violations of the ESA, Administrative Procedure Act (APA) and the National Environmental Policy Act (NEPA) in connection with this consultation. Defendants filed their answer on November 16, 2007. Plaintiffs and Defendants agreed to a Stipulated Settlement Agreement, dated February 26, 2008. The Settlement Agreement includes, among other things, agreement by the Services to complete their Opinions by July 11, 2008.

1.3 CONSULTATION WITH AFFECTED INDIAN TRIBES

The Secretarial Order: American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and Endangered Species Act (SO) clarifies the responsibilities of the Departments of Commerce and the Interior when actions or regulations under the ESA "may affect Indian lands, tribal trust resources, or the exercise of American Indian tribal rights." The SO further states, "The Departments will carry out their responsibilities under the Act in a manner that harmonizes the federal trust responsibilities to tribes, tribal sovereignty, and statutory missions of the Departments." Specifically, NMFS is directed to solicit relevant information from the tribes should they wish to offer any, and to encourage Action Agencies to include affected Tribes in their consultation process.

On October 3, 2001, NMFS contacted tribal fisheries managers alerting them to the Willamette Project ESA consultation and proposing to hold an informational meeting with them. The following Tribes were contacted: Confederated Tribes of the Warm Springs Reservation (CTWS), Yakama Indian Nation (Yakama), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Nez Perce Tribe, Confederated Tribes of Siletz Indians (CTSI), and Confederated Tribes of the Grand Ronde Community of Oregon (CTGR). On November 13, 2001, the Services and Action Agencies met jointly with technical representatives of CTSI, CTWS, and CTGR for initial coordination regarding the scope and content of the Willamette Project ESA consultation. Representatives from all three Tribes expressed interest in the consultation, especially as it might affect harvest of salmon and Pacific lamprey (*Lampetra tridentata)* at Willamette Falls.

By letters to tribal council leaders dated February 14, 2008, NMFS notified the tribes listed above, as well as the Columbia River Inter-Tribal Fish Commission (CRITFC), each of whom may potentially have an interest in the Proposed Action, of its ESA consultation regarding the Willamette Project. Copies of these letters were also sent to designated contact personnel in their respective tribe's natural resources or fisheries programs. The letters summarized the purpose of this consultation and solicited information, traditional knowledge or comments the tribes might provide to help in the consultation. The letters also invited the tribes to participate in an informational meeting about the Willamette Project and this consultation, hosted jointly by the Services and Action Agencies, to be held on May 5, 2008. Subsequently, NMFS staff contacted designated personnel at each tribe to discuss the proposed action and to seek the tribe's perspective on potential effects of the proposed action on any Tribal resources and rights.

Tribal biologists or attorneys, or both, from the CTWS, CTUIR, CTSI, and CTGR attended the May 5, 2008 meeting. The Tribal Council Chairman of CTWS also participated. Additionally, technical staff from CRITFC and U.S. Bureau of Indian Affairs (BIA) were present. At that meeting, the Action Agencies described the Willamette Project and conservation measures proposed in the Supplemental BA (USACE 2007a). NMFS and USFWS presented summaries of each agency's respective draft biological opinions, including the RPA measures that NMFS was proposing to include in its jeopardy opinion for UWR Chinook salmon and UWR steelhead. Tribal representatives were invited to ask questions and provide information and verbal comments.

Tribal representatives at the May 5, 2008 meeting requested an opportunity to review the draft Opinion. In response, NMFS invited tribal representatives to view copies of the draft Opinion at NMFS' Northwest Regional Office in Portland, Oregon. On May 22, 23, and 27, tribal representatives from CTUIR, CTWS, CTGR, and CRITFC reviewed the April 30, 2008 draft Opinion. NMFS staff were available to answer questions and listen and respond to verbal comments.

Following this opportunity to review the draft opinion, CTUIR and CRITFC representatives requested an informal meeting with NMFS staff to discuss their concerns. This meeting was held on June 2, 2008. CTWS, CTUIR, YIN, and CRITFC representatives requested another informal meeting with NMFS policy and technical staff, which was held on June 19, 2008. At this meeting, tribal representatives discussed three primary issues: tribal participation and roles in implementation structure, lamprey protection, and tribal participation in studies and decisions related to fish passage, flows, and other RPA measures. NMFS responded that the RPA coordination implementation process included tribal participation. Additionally, NMFS indicated that it would propose consideration of lamprey protection and tribal participation in studies and other measures in its recommended conservation measures.

1.4 LISTED SPECIES OCCURRING WITHIN THE ACTION AREA

There are 13 ESA-listed salmon and steelhead species that may be affected by the Proposed Action. Species that may be affected by this action include: UWR Chinook salmon (*O. tshawytscha)*, UWR steelhead (*O. mykiss*), Lower Columbia River (LCR) Chinook salmon, LCR coho salmon *(O. kisutch)*, LCR steelhead, Middle Columbia River (MCR) steelhead, Columbia River (CR) chum salmon *(O. keta)*, Snake River (SR) spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon *(O. nerka)*, SR steelhead, Upper Columbia River (UCR) spring Chinook salmon, and UCR steelhead. The listing status and critical habitat designations for each of the species that may be affected by the Proposed Action are identified in Table 3-1.

Except for LCR coho salmon, critical habitat has been designated for all of the anadromous fish potentially affected by the Proposed Action.

Southern Resident killer whales are listed as endangered and the Southern DPS of North American green sturgeon is listed as threatened under the ESA. Both species may be affected by the actions discussed in this consultation. After conducting the analyses included as Appendices A and B to this Opinion, NMFS determines that the Proposed Action and the RPA are not likely to adversely affect either species or critical habitat designated for the Southern Resident killer whale.

1.5 APPLICATION OF ESA SECTION 7(A)(2) STANDARDS – ANALYTICAL APPROACH

This section describes NMFS' approach to applying the standards for determining jeopardy, and destruction or adverse modification of critical habitat that are set forth in the ESA's Section 7(a)(2) and in 50 CFR 402.02 (the consultation regulations). Additional details regarding this analysis are provided by the *Endangered Species Consultation Handbook*, issued jointly by the Services (USFWS and NMFS 1998). In conducting analyses of actions under the ESA's Section 7 and as directed by the consultation regulations, NMFS follows these steps:

- Identifies the action area based on the action agency's description of the proposed action, and describes the proposed action (Section 2 of this Opinion).
- Evaluates the current status of the listed species with respect to biological requirements indicative of survival and recovery and the primary constituent elements (PCEs) of any designated critical habitat (Section 3 of this Opinion).
- Evaluates the relevance of the environmental baseline in the action area to the species' biological requirements and the current status within the action area, as well as the status of any designated critical habitat (Section 4 of this Opinion).
- Determines whether the proposed action reduces the abundance, reproduction, or distribution of the species, or negatively alters any PCEs of designated critical habitat within the action area (Section 5 of this Opinion).
- Determines and evaluates any cumulative effects within the action area (Section 6 of this Opinion).
- Evaluates whether the effects of the proposed action, taken together with cumulative effects and the effects within the environmental baseline, can be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the affected species, or are likely to destroy or adversely modify critical habitat (Section 7 of this Opinion; see CFR 402.14(g)).

The jeopardy standard is survival with an adequate potential for recovery. We apply this standard for the Willamette consultation in such a way that we determine the effects of the Proposed Action, analyze whether these effects appreciably reduce the likelihood of the species survival and recovery, and determine whether the proposed action contributes to survival with an adequate potential for recovery. If, in completing the last step of the analysis, NMFS determines that the action is likely to jeopardize the ESA-listed species or adversely modify critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the proposed action that avoids jeopardy or adverse modification of critical habitat by contributing towards the species survival with an adequate potential for recovery. (see CFR §402.02). In making these determinations, NMFS must rely on the best available scientific and commercial data.

In the critical habitat analysis, NMFS determines whether the proposed action will destroy or adversely modify designated or proposed critical habitat for ESA-listed species by examining any change in the conservation value of the PCEs of that critical habitat. This analysis focuses on statutory provisions of the ESA, including: Section 3, which defines "critical habitat" and "conservation"; Section 4, which describes the designation process; and Section 7, which sets forth the substantive protections and procedural aspects of consultation. This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.2. Instead, NMFS relies upon the Hogarth memo (NMFS 2005b).

1.6 Term of the Opinion

The term of this PA and the Opinion and incidental take statement is through 2023, and encompasses completion of certain major structures intended to improve fish passage and water quality at high priority Project dams, and includes monitoring and evaluations necessary to design effective structures and assess measures in the Proposed Action. Additional major structures and other measures may be in completed after 2023, but steps towards their completion are part of this consultation. NMFS may choose, based on the best available information, to extend this Opinion and the incidental take statement at the request of the Action Agencies. NMFS will determine whether an extension is appropriate, and if so, NMFS will also determine the appropriate length of the extension.

1.7 Conclusions

In this Opinion, NMFS concludes that the Proposed Action would jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and would destroy or adversely modify their critical habitat because it does not adequately address adverse effects of the dams, revetments and hatcheries on listed fish and their habitat, factors that are suppressing the viability of both species and are contributing to the high risk of extinction for UWR Chinook. NMFS therefore provided the Action Agencies with a Reasonable and Prudent Alternative (RPA), a package of measures that allows for the survival with an adequate potential for recovery for these two species. A number of the RPA measures will provide benefits in the short-term, reducing each species' short-term risk of extinction, including measures to improve downstream habitat by changing flows and temperature, updating hatchery operations and facilities, improving irrigation diversions and water contracts, upgrading fish collection facilities and outplanting procedures, and conducting habitat improvement projects. These measures will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the short-term risk of extinction. This is especially important for UWR Chinook salmon, for which the risk of extinction is "high."[1] Project operations have had a key role in

[1] The Willamette/Lower Columbia Technical Recovery Team (WLCTRT) (McElhany et al. 2007) estimated the risk of extinction over 100 years for UWR Chinook ("high;" see Figure 3-5 in Section 3.2.1.3). The TRT did not estimate the species' short-term extinction risk.

degrading habitat conditions downstream, which in the North and South Santiam, South Fork McKenzie, and Middle Fork Willamette are the only areas still accessible to Chinook for spawning, incubation, and early rearing. The Action Agencies began new reservoir operations in 2000 to meet mainstem and tributary flow objectives for both listed Chinook and steelhead. These, and operations that began in 2005 at the new Water Temperature Control facility at Cougar Dam, are already able to have a positive influence on adult Chinook returns. Under the RPA, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and prespawning adults of both species and thus population productivity. All of these measures will reduce extinction risk in the short term as well as contributing to long-term viability.

The RPA includes a number of measures that will be completed in the second half of the term of the Opinion, the eighth to fifteenth years. These include three significant passage facilities at three dams and temperature control at a different dam, as well as other measures. These measures will contribute significantly to both species' survival and potential for recovery. The RPA also requires that the Action Agencies complete various research and monitoring efforts, feasibility studies, and where needed, environmental impact analysis. These evaluations will lead to the construction of facilities and adjustments in operations during the second half of the term of this Opinion that will ensure that conditions are significantly improved for all affected life stages of UWR Chinook and UWR steelhead. These will include further adjustments to flows, passage at three projects, and temperature control at another. The Action Agencies will adapt their operations to new information as well as physical habitat properties, including those related to climate change, as the information becomes available over the next 15 years.

Outside of the Willamette Basin, adverse effects of the Proposed Action are limited to very small changes in flows in the mainstem lower Columbia with slight to negligible effects on listed salmonids and their habitat. NMFS concludes that the Proposed Action does not jeopardize the continued existence of the other 11 species of Interior and Lower Columbia Basin salmon and steelhead, which are affected by the Proposed Action only in that portion of the action area. NMFS also concludes that the Proposed Action avoids any destruction or adverse modification critical habitat for the ten Interior and Lower Columbia Basin species for which it has been designated. NMFS determines that the Proposed Action and the RPA are not likely to adversely affect the Southern Resident killer whale DPS or the Southern DPS of North American green sturgeon, or to destroy or adversely modify critical habitat designated for the Southern Resident killer whale.

Chapter 2
Proposed Action

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2. PROPOSED ACTION

2.1 GENERAL DESCRIPTION & PURPOSES OF THE WILLAMETTE PROJECT

This chapter provides a summary of the Federal action under consultation, the continued operation of the Willamette Project. The proposed action described in the 2000 Biological Assessment (USACE 2000) represented the operation of the Willamette Project at the time of the 1999 listing of UWR winter steelhead and spring Chinook as threatened under the ESA. The proposed action at that time included few actions or measures to conserve ESA-listed species or their habitats. Subsequently, the Action Agencies have modified system operations as described in the Supplemental BA, (USACE 2007a), and proposed new measures in the Supplemental BA to minimize ongoing effects to listed species and to restore habitat affected by the Project. For this consultation, NMFS considers the Proposed Action to be:

- operations and facilities described in the 2000 BA that were not modified by the 2007 Supplemental BA,
- operations in the 2000 BA that *were* modified by the 2007 BA,
- new operations and measures proposed in the 2007 Supplemental BA.

The Willamette Project is a collection of actions that include the operation of 13 USACE dam and reservoir complexes, existence and maintenance of approximately 42 miles of revetments,[1] and operation and maintenance of four hatcheries and related fish collection and holding facilities.

The USACE began the Willamette Project by constructing Fern Ridge Dam near Eugene in 1941 as the first element of the Willamette Basin Plan. Over the next 20 years, the USACE constructed twelve additional dams as part of this Project: Cottage Grove (1942); Dorena (1949); Detroit (1953); Lookout Point, Dexter, and Big Cliff (1954); Hills Creek (1961); Cougar (1963); Fall Creek (1966); Green Peter and Foster (1968); and Blue River (1969). Big Cliff and Dexter are reregulation projects, linked to operation of the Detroit and Lookout Point projects, respectively. Foster serves as both a storage reservoir and as a reregulation facility for Green Peter. The 13 projects are shown in Figure 2-1 and general operational restrictions for each are described in Table 2-1. In conjunction with these, numerous fisheries mitigation facilities were also built, and other ancillary support facilities.

Besides their use for flood control, the USACE reservoirs in the Willamette Basin contain approximately 1,593,700 acre-ft of usable multiple-use storage (Table 2-1). They release stored water from mid-April until the end of November in a manner that supports other Project purposes such as irrigation, navigation, power generation, recreation, instream flows below projects for aquatic life, wildlife, and municipal and industrial water supply (USACE 2000). Eight of the dams have power generation capability.

[1] Revetments are fortified riverbank sections intended to constrain the meandering of rivers.

Figure 2-1 Principal Corps of Engineers facilities in the Willamette Basin.

Table 2-1 Operational Data for Willamette Basin Projects

Project	Minimum Flood Control Pool	Maximum Conservation Pool	Total Conservation Storage	Minimum Authorized Flow Feb - June	Minimum Authorized Flow July - Nov[2]	Drawdown Priority
	Feet (NGVD)[3]	Feet (NGVD)	Acre-Feet	cfs	cfs	
Hills Creek	1,448.0	1,541.0	194,000	100	100	4th
Lookout Point	825.0	926.0	324,200	1,200	1,000	1st
Fall Creek	728.0	830.0	108,200	30	30	5th
Cottage Grove	750.0	790.0	28,600	75	50	5th
Dorena	770.0	832.0	65,000	190	100	5th
Cougar	1,532.0	1,690.0	143,900	300	200	2nd
Blue River	1,180.0	1,350.0	78,900	50	30	3rd
Fern Ridge	353.0	373.0	93,900	50	30	last
Green Peter	922.0	1,010.0	250,000	300	300	5th
Foster	613.0	637.0	248,000	600	400	last
Detroit	1,450.0	1,563.5	281,600	1,000	750	last
Big Cliff[4]						
Dexter						
Total			1,593,700	3,895	2,990	

2 During a drought, project releases may be cut back to "Minimum Authorized Flows" or below after coordination with State and Federal agencies.

3 National Geodetic Vertical Datum.

4 Big Cliff and Dexter are reregulating dams that have no appreciable storage.

2.2 WILLAMETTE PROJECT ADMINISTRATION, ROLES OF USACE, BPA, RECLAMATION

The USACE's Portland District is the primary Federal agency responsible for operation and maintenance of the Willamette Project; however, Reclamation (Reclamation) and the BPA also have important roles, as described in this section.

2.2.1 US Army Corps of Engineers' Roles

2.2.1.1 Flow Management

Flow management (including flood prevention) of the Willamette Project is the responsibility of the USACE's Portland District.[5] The Portland District's responsibilities include coordination among agencies and interested parties and development of plans for water management within the basin. The Portland District coordinates competing demands from power interests, irrigation demands, minimum stream flow requirements, recreational users, and others parties during plan development. Seasonal planning for the spring and summer is based in part on seasonal forecasts by the Natural Resources Conservation Service (NRCS).

The USACE Northwest Division's Reservoir Control Center (USACE) is responsible for reservoir regulation and flow management on a daily basis and makes the daily decisions regarding regulation of flow and storage in the Willamette Basin. The USACE's daily decisions on flow releases are based in part on the hydrologic model maintained by the National Weather Service River Forecast Center, while taking into account current reservoir elevations and inflows, the forecast for precipitation, current snow pack conditions, and runoff conditions. The Portland District coordinates USACE operations with BPA, Reclamation, NMFS, USFWS, ODFW, the Oregon Water Resources Department (OWRD), the City of Springfield, and other concerned governmental entities.

2.2.1.2 Revetment Existence & Maintenance

The USACE in the past built about 93 miles of revetments[6] on the Willamette River and its tributaries as a component of the Willamette Project (USACE 2000). Of the 138 sites that the USACE built, it is directly responsible for 88 sites, equal to about 42 miles, constructed prior to 1951. The USACE has relinquished actual ownership of the other 50 revetment sites to adjacent riparian landowners, but continues to administer programs[7] for their repair and maintenance (USACE 2007a).

[5] In addition, USACE coordinates water releases from their dams with releases from non-USACE dams in the Willamette Basin such as those owned by Portland General Electric on the Clackamas River and Reclamation's Scoggins Dam on the Tualatin River in order to meet downstream flow targets during floods.

[6] Reinforced riverbanks that constrain the river from meandering.

[7] Emergency Assistance Program under Public Law 84-99 (USACE 2000, pp. 2-80) and Section 404 of the Clean Water Act (USACE 2000, pp. 1-25), for example.

2.2.1.3 Hatchery Program

In the Willamette Basin, the USACE operates five fish hatcheries and four satellite facilities used for adult collection, holding, and spawning, rearing, and/or acclimation. These facilities were originally intended to mitigate for anticipated adverse fisheries impacts of the Willamette Project such as blocked fish access to historic habitat above dams and altered downstream water temperatures and flow regimes.

There are also several fish traps that are either adjunct facilities of the hatchery program, or, in some cases (Green Peter/Foster, Cougar, and Fall Creek, for example) were intended to provide continued means for fish to access habitat that was otherwise blocked by dams. USACE operates some of these traps itself, contracts with ODFW to operate others, and discontinued use of other facilities that did not function correctly.

2.2.2 US Bureau of Reclamation's (Reclamation, Pacific Northwest Regional Office) Roles

Reclamation is responsible for the administration of a water marketing program that sells water stored in USACE reservoirs to agricultural users.[8] The existence of the USACE reservoirs results in more summer flows being available for irrigated agriculture than would naturally occur. Reclamation does not operate any of the physical facilities (such as dams, pumps, and canals) of the Willamette Project.

2.2.3 Bonneville Power Administration's Roles

The BPA transmits and markets electrical power generated by those USACE Willamette Project dams that have power producing facilities. Eight of the USACE-owned and operated dams in the Willamette Project produce power for BPA, which pays for approximately 37% of the capital, operations, and maintenance costs of those eight projects (USACE 2000). The Willamette Project generates approximately 184 average annual megawatts (aMW) with annual market value of $82.8 million (Foudrea 2007). BPA also builds and operates transmission lines that deliver the electricity.

The Northwest Power Act requires BPA to fund protection, mitigation, and enhancement activities. A portion of BPA's power-derived revenues are used to mitigate the adverse effects of the hydroelectric systems through funding a variety of mitigation projects throughout the Columbia Basin, including the Willamette Basin.

2.3 PROJECT PURPOSES & RESPONSIBILITIES

The following subsections summarize features or aspects of the Willamette Project that are common to several or all facilities and that pertain to specific authorized and incidental purposes of the Willamette Project. These project purposes are described below, and include flood control, irrigation water supply, municipal and industrial water supply, navigation, flow

[8] Non-agricultural water contracts, such as for municipal or industrial use, for example, would not be administered by Reclamation, but rather by USACE. There are no non-irrigation contracts currently, however.

augmentation, hydroelectric power, recreation, fish and wildlife conservation, and system operation. This section also includes a brief description of the USACE's ongoing land management, bank protection, and emergency assistance programs.

2.3.1 Flood Control

Flood control is a principal purpose of the Willamette Project. Willamette reservoirs are drawn down to minimum flood control pool between September and December according to established operating protocols that take into account various water management objectives as well as flood control.[9] The primary flood control season begins in December and ends in late January. During the flood control season the reservoirs are drawn down to and kept at minimum flood-control levels (called "minimum flood-control pool") so that water can be stored during flood events[10] for subsequent controlled release. Operations during flood events have resulted in quick reductions in project releases, sometimes in a matter of hours, in order to prevent overbank or flooding conditions at control points located immediately downstream of each project and at other locations in the system (Table 2-2). Flood regulation goals for the Middle Fork and mainstem Willamette River are presented in Table 2-3. A representative flood control operation is depicted in Figure 2-2.

Table 2-2 Principal Downstream Flood Control Points for Willamette Basin Projects (USACE 2000 Table 2-2).

Project	River	Downstream (River) Control Points
Detroit	North Santiam	Mehama (North Santiam); Jefferson (Santiam); Salem (mainstem Willamette)
Green Peter	Middle Santiam	Waterloo (South Santiam); Jefferson (Santiam); Salem (mainstem Willamette)
Foster	South Santiam	Waterloo (South Santiam); Jefferson (Santiam); Salem (mainstem Willamette)
Blue River	Blue	Vida (McKenzie); Harrisburg (mainstem Willamette)
Cougar	McKenzie	Vida (McKenzie); Harrisburg (mainstem Willamette)
Fall Creek	Fall Creek	Jasper (Middle Fork Willamette); Harrisburg (mainstem Willamette)
Hills Creek	Middle Fork Willamette	Jasper (Middle Fork Willamette); Harrisburg (mainstem Willamette)
Lookout Point	Middle Fork Willamette	Jasper (Middle Fork Willamette); Harrisburg (mainstem Willamette); Salem (mainstem Willamette)
Dorena	Row	Goshen (Coast Fork Willamette); Harrisburg (mainstem Willamette)

9 As an example, between mid-September and mid-October, salmon spawn downstream of Cougar, Dexter (Lookout Point), and Big Cliff (Detroit) dams. The State's water management objectives include trying to keep flow levels constant and within site-specific ranges so that salmon redds are not dewatered.

10 It is not uncommon to experience floods while still in the drawdown mode.

Project	River	Downstream (River) Control Points
Cottage Grove	Coast Fork Willamette	Goshen (Coast Fork Willamette); Harrisburg (mainstem Willamette)
Fern Ridge	Long Tom	Monroe (Long Tom); Salem (mainstem Willamette)

Table 2-3 Representative Downstream Control Points on the Middle Fork and Mainstem Willamette Rivers (USACE 2000 Table 2-3).

Gauging Station	ID Number	Willamette River Mile Distance	Drainage Area (mi^2)	Flood Regulation Goals (cfs)
Middle Fork Willamette River near Jasper, OR	USGS 14152000	RM 195.0	1,340	20,000
Willamette River at Eugene, OR	USACE CBT Code "EUGO"	RM 182.4	2,030	39,000
Willamette River at Harrisburg, OR	USGS 14166000	RM 161.0	3,420	45,000
Willamette River at Albany, OR	USGS 14174000	RM 119.3	4,840	70,000
Willamette River at Salem, OR	USGS 14191000	RM 84.2	7,280	90,000

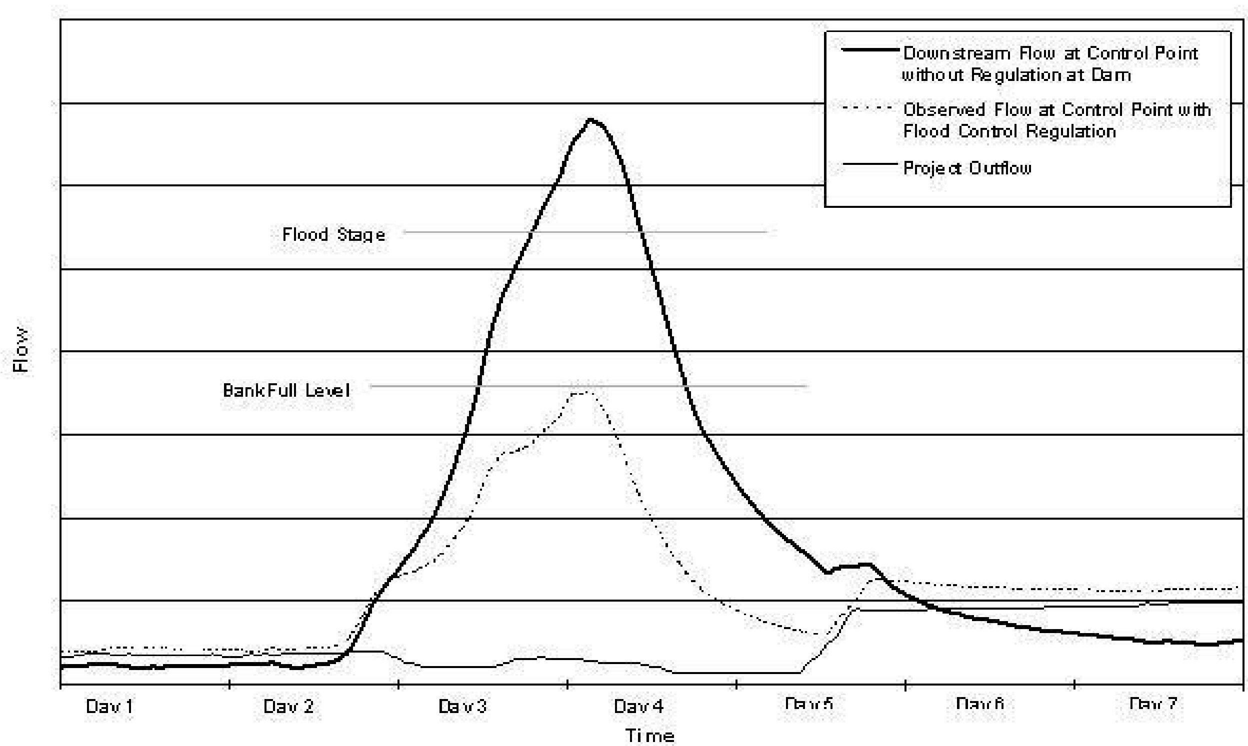

Figure 2-2 Typical Flood control Operating Strategy of Willamette Project Facilities (USACE 2000 Figure 2-1).

The USACE assesses storm tracks and the antecedent conditions in each sub-basin to determine which projects are subject to controlled releases during any given flood event. USACE makes use of real-time continuous monitoring of hydro-meteorological conditions in and near the basin when it prepares flood forecasts and schedules project releases, generally for the next 72-hour period, in 6-hour increments. Inflow is generally passed through each project until flood forecasts predict that outflows must be reduced to prevent project releases from combining with uncontrolled local flow from downstream areas to exceed flood regulation goals at the downstream control points. After flows have receded and the danger of flooding has passed, the USACE coordinates the release of stored flood water among the projects to prevent overbank conditions downriver, and to return the reservoir to the minimum flood-control pool in anticipation of the next potential flood.

Downward ramping rates (rates of change in dam discharges) or upward ramping rates are set by the USACE, and depend on factors such as weather, flow forecasts, and flood control storage, which result in a high or low flow situation. During a high flow situation, ramping rates for reducing or increasing releases can be rapid in order to meet flood control goals. During a low flow situation, ramping rates are more restrictive with respect to hourly and daily changes in order to avoid rapid fluctuations in flow levels. If the forecast flood runoff volume indicates that reservoir space would be exceeded, a special flood regulation schedule is used. This special schedule calls for gradual increases in reservoir releases to avoid sudden increases in outflow as each reservoir fills.

Flood control space in power-producing reservoirs is divided between primary and secondary storage.[11] Evacuation of water stored in the primary flood control zone is made through spillway and/or regulating outlets as rapidly after a flood as downstream conditions permit. Water constituting secondary flood control space is generally discharged through the turbines. The optimal power generation situation occurs when it is possible to discharge all of secondary flood control space and reservoir inflows through the power turbines, thereby avoiding the loss of power generation that would occur if water were to pass through non-turbine outlets. However, the power turbines have limited capacity and at times additional releases must be made through regulating outlets and/or spillways to evacuate more rapidly to minimum flood-control pool levels. The maximum evacuation releases for normal flood control regulation at each project are listed in Table 2-4.

[11] Primary flood control storage is that space needed to control floods that statistically have a 2% chance of happening in any year (50-year flood). Secondary flood control storage provides additional space to control larger floods that statistically have a 1% chance of occurring (100-year flood).

Table 2-4 Maximum evacuation releases Evacuation Releases (cfs) for Normal Flood Control Regulation, as Measured at Downstream Control Points (USACE 2000 Table 2-4).

	Coast Fork Willamette at Goshen	Middle Fork Willamette at Jasper	McKenzie at Vida	Willamette at Harrisburg	Long Tom at Monroe	Willamette at Albany	N. Santiam at Mehama	S. Santiam at Waterloo	Santiam at Jefferson	Willamette at Salem
Cottage Grove	3,000			3,000		3,000				3,000
Dorena	5,000			5,000		5,000				5,000
Hills Creek		8,000		8,000		8,000				
Lookout Point		15,000		15,000		15,000				15,000
Fall Creek		4,500		4,500		4,500				4,500
Cougar			6,500	6,500		6,500				6,500
Blue River			3,700	3,700		3,700				3,700
Fern Ridge					3,000	3,000				3,000
Green Peter								11,000	11,000	
Foster								18,000	18,000	18,000
Detroit							17,000		17,000	17,000
Total Evacuation[1]	8,000	19,500	10,200	37,700	3,000	40,700	17,000	18,000	35,000	75,700
Bankfull Flow[2]	12,000	20,000	14,500	42,000	6,000	70,000	17,000	18,000	35,000	90,000
Regulation Goal	12,000	20,000	14,500	42,000	4,650	70,000	17,000	18,000	35,000	90,000

[1] Above control point

[2] At control point

Floods are less likely to occur from February through early May. This period is referred to as the conservation storage season. Storage space in the reservoirs is filled gradually during this period for later use for purposes such as irrigation, recreation, power production, and water quality. Each project has a refill rule curve that provides guidance in refilling a project in a controlled manner to desired reservoir elevations by specific dates. However, departures from refill rule curves may result from regulation of floods, excessive snow pack above the reservoirs, inadequate water supply, or critical power needs. Excess flood water stored above the rule curve during the conservation storage season is evacuated in accordance with downstream channel capacity. However, when the water supply is inadequate to maintain both minimum flows and the scheduled rate of filling, maintaining minimum instream flows downstream of the facility generally takes precedence. Deficiencies in storage can be made up at any time beyond early May when the water supply is adequate. Refill of a project can also be delayed when excessive snow pack above the reservoirs causes concern for flooding.

2.3.2 Irrigation Water Supply

Congress identified irrigation as a major purpose in project authorizing legislation. Collectively, the total joint-use conservation storage at all 13 projects totals approximately 1.6 million acre-ft (USACE 2000, Table 2-1). Reclamation is responsible for management and development of contracts for use of irrigation water that is stored at USACE projects. On behalf of the Federal government, Reclamation obtained two water rights certificates (No. 72755 and 72756) from the State of Oregon for a total of 1,640,100 acre-ft of stored water for irrigation use only. Specific proposed action measures regarding use of stored water for irrigation are described below in Table 2-13, in Section 2.9 (Water Marketing Program).

2.3.3 Municipal & Industrial Water Supply-

Initially, Congress authorized Reclamation to issue contracts for stored water for agricultural purposes only. However, the Flood Control Act of 1950 reauthorized and expanded authorization to the USACE to construct and operate the Willamette Project, as described in HD 531, and included municipal and industrial water supply as an intended and authorized project purpose (USACE 2000). USACE has not issued any contracts to municipal or industrial users, but USACE may reallocate existing storage space and use by municipal or industrial users at a later time, if necessary.

2.3.4 Navigation

The Action Agencies are not proposing any measures for navigation except for flow augmentation. Navigation remains an authorized purpose for the upper Willamette River above Willamette Falls. In 1871, Congress authorized the first plan for improving the channel between Portland and Eugene (River and Harbor Act of 1871). The plan has been modified several times since to provide for such things as an 8-ft channel between Portland and Oregon City and a 2.5- to 3.5-ft deep channel between Oregon City and Albany, both of which the USACE completed in 1939. A 2.5- to 3.5-ft deep channel was completed between Albany and Corvallis in 1945. On the Yamhill River, a dam and lock at river mile (RM) 8 provided the 18-mile channel to McMinnville, but due to lack of use by commercial traffic, operation of the Yamhill Lock was discontinued in 1954, with the lock and adjacent property turned over to Yamhill County in 1959 for a park. Uncompleted work on the upper navigation channel consisted of channel improvements and streamflow regulation to control depths of 6 ft at low water from Oregon City to the mouth of the Santiam River and 5 ft from that point to Albany. The USACE maintained the completed portion of the navigation channel to the vicinity of Corvallis until 1973 when commercial navigation traffic declined to a point where further maintenance could not be justified. The portion between Corvallis and Eugene was de-authorized by the Water Resources Development Act of 1986. In the early 1990s, the Mid-Valley Council of Governments investigated the feasibility of deepening the upper Willamette River navigation channel between Newberg and Independence to facilitate recreational and commercial boat traffic. The study found it was not cost effective to deepen the navigation channel at that time.

An element of the upper Willamette River navigation project is the Willamette Falls Locks at RM 26 above the mouth of the Willamette River in the city of West Linn, Clackamas County, Oregon. The canal and locks were first constructed by private interests in 1873. The USACE surveyed the locks and in 1899, recommended government ownership. The project was authorized by the Rivers and Harbors Act of 1910 (Public Law 61-264) and the Federal government purchased the locks in 1915. The existing project consists of four locks each with a vertical lift of about 10 ft, a canal basin, and a guard lock used to prevent flooding when river levels are high. From 1987 to 1993, an annual average of about 5,700 vessels passed through the locks. In 1974, the locks were placed on the National Register of Historic Places. In 1991, the locks also were established as an Oregon Civil Engineering Landmark.

The Flood Control Act of 1938 and the Rivers and Harbors Act of 1945 authorized modifications to the Willamette Falls Locks including a new single lift main lock and a guard lock to replace the existing facilities; however, this project was de-authorized by the Water Resources Development Act of 1986 because navigation did not develop as anticipated. Though the locks last operated from May to October in 2007, continuance of lock operations is uncertain due to funding and maintenance limitations.[12]

2.3.5 Flow Augmentation

Project authorizing documents (HD 544, 75th Congress, third session, March 16, 1938) stipulated a minimum flow of 5,000 cfs between Albany and the Santiam River, and 6,500 cfs downstream to Salem to provide navigation depths of 6 ft and 5 ft, respectively, above Willamette Falls. It was also recognized in HD 544 that these navigation flows would increase flows during the low-water period and would "benefit sanitary conditions along the mainstream" by diluting wastes and increase "the dissolved oxygen content of the stream with a resultant beneficial effect on fish life." HD 531, 81st Congress, second session, March 20, 1950, also stipulates the above minimum flows to allow open-river navigation from Portland to Corvallis and recognizes that these flows would reduce pollution concentrations in the river, and would make oxygen available for fish life. The water quality and fishery strategies for the Willamette River are currently based on the navigation flow requirements originally established at Albany and Salem.

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[12] Willamette Falls Historical Foundation (http://Willamettefalls.org/HisLocks)

The 2000 BA describes the USACE's system operations to augment flows in the mainstem Willamette. These operations and flow levels have been modified since then, and the 2007 Supplemental BA provides updated information. The revised proposed actions regarding mainstem Willamette and tributary flow objectives are described later in Section 2.8.

2.3.6 Hydroelectric Power Generation

Hydroelectric power facilities are installed at eight of the 13 USACE projects in the Willamette Basin: Hills Creek, Lookout Point, Dexter, Cougar, Green Peter, Foster, Detroit and Big Cliff; electrical energy generated at these projects is marketed by BPA. There are two types of Federal hydropower projects in the basin: storage and reregulation. Lookout Point, Detroit, and Green Peter are storage projects and are associated with reregulation dams located downstream (Dexter, Big Cliff, and Foster, respectively). The Foster project also acts as a storage facility. The Hills Creek and Cougar storage projects do not have reregulation dams located downstream. Power facilities do not exist presently at the Fall Creek, Blue River, Dorena, Cottage Grove, or Fern Ridge projects. However, non-federal entities are seeking permits to install hydropower projects at Dorena and Fall Creek.

Power generation at Willamette Project dams is generally linked to releases for other Project purposes such as flood control and environmental needs, though some flexibility exists to generate electricity at different levels throughout the day and during different seasons. Projects with hydropower facilities include exclusive storage space for power generation, but the quantity of storage is relatively small. Drawdowns into power storage are limited to special power requirement periods that may develop during extended cold spells. In general, exclusive power storage is kept full to increase the hydraulic head for power generation. Generation at storage (peaking) projects is often correlated with daily and weekly fluctuations in power demand (load), and flows downstream are therefore subject to frequent fluctuations that require reregulation. Reregulation reservoirs (Big Cliff, Dexter, Foster) are used to moderate flow fluctuations from associated upstream storage projects in order to reduce adverse affects on aquatic and human habitat and life below.

The average monthly generation in megawatts from 1983 to 1995 for each of the Willamette hydropower projects is shown in Table 2-5. The larger, high-head projects of Detroit, Green Peter, Lookout Point, and Cougar generate considerably more power than the lower-head reregulation dams of Big Cliff, Foster, and Dexter. Generation can change drastically from year to year depending on the amount of runoff that occurs in a basin.

Table 2-5 Average monthly power generation (in megawatts), Willamette basin projects (1983-1995). (from USACE 2000 Table 3-8)

Month	Detroit	Big Cliff	Green Peter	Foster	Cougar	Lookout Point	Dexter	Hills Creek	TOTAL (MW)
January	52	14	42	15	17	38	11	20	209
February	38	10	22	12	11	28	6	13	139
March	36	9	21	12	10	28	6	13	134
April	36	10	23	13	15	32	6	16	149
May	51	12	27	11	19	47	9	21	197
June	42	10	18	9	16	40	7	18	161
July	26	6	12	5	14	27	6	10	105
August	23	5	13	0.5	22	33	8	10	119
September	43	11	23	89	22	37	10	28	182
October	56	16	26	12	21	36	10	27	203
November	65	17	52	16.7	18.7	53	13	26	262
December	58	15	58	18	19	46	12	23	245
TOTAL	527	134	333	136	205	446	103	222	2105

2.3.7 Recreation

Recreation use and development is authorized at all the USACE's projects under Federal legislation, including the Federal Water Projects Recreation Act of 1964 (Public Law 89-72) and the Flood Control Act of 1944. Under these authorities, USACE is primarily responsible for providing recreation facilities. The USACE cooperates with the U.S. Forest Service (USFS), Oregon State Parks, ODFW, and Linn and Lane Counties to build and manage a system of water-related recreation facilities. Recreation facilities are provided at all of the USACE's projects and along most of the downstream reaches. Annual visitation to the reservoirs includes 3.6 million recreation visits to USACE-managed areas, in addition to the estimated 700,000 visits to USFS areas managed by the State of Oregon (including Detroit State Park) and county parks located on the reservoirs.

In recent years, the USACE has received increased pressure from reservoir recreational interests and marina operators to maintain reservoirs at high levels throughout the entire recreational season (nominally Memorial Day through Labor Day), such as at Detroit where docks, boat ramps, and other facilities become difficult or impossible to use as the water surface lowers. As a result, the USACE has established a drawdown priority for the projects (Table 2-6). Those projects with the highest recreation demand are the last to be used for meeting flow requirements at Albany and Salem, so their pool elevations are usually are held high until early September. This can result in the tributaries into which they discharge having less water than is optimal for other purposes, fisheries and water quality, for example. On the other hand, those projects with lower recreation demand are used first for meeting summer mainstem Willamette flows, and are drawn down earlier, and may have higher than proportional tributary flows downstream of their dams. The three most important recreational lakes in the system, Detroit, Fern Ridge, and Foster, are usually the last to be evacuated to meet summer flow requirements.

Table 2-6 Priorities of Willamette Basin Storage Projects (USACE 2000 Table 2-9).

	Drawdown Order for Augmenting Summer Stream Flow	Priority Purposes (USACE 1989)				
		Flood Control[1]	Power Generation	Recreation[2]	Navigation	Irrigation
Detroit	Last	✓	✓	✓	✓	✓
Big Cliff	NA		✓			
Green Peter	5th	✓	✓		✓	✓
Foster	Last	✓	✓	✓	✓	✓
Blue River	3rd	✓			✓	✓
Cougar	2nd	✓	✓		✓	✓
Fall Creek	5th	✓			✓	✓
Hills Creek	4th	✓	✓		✓	✓
Lookout Point	1st	✓	✓		✓	✓
Dexter	NA	✓	✓		✓	✓
Dorena	5th	✓		✓	✓	✓
Cottage Grove	5th	✓		✓		
Fern Ridge	Last	✓		✓	✓	✓

Notes:
1. Has highest priority to ensure public safety
2. during summer months

2.3.8 System Operation

The 13 Project dams are operated as a system. Seasonal regulation of each reservoir is guided by the flood control rule curves for that reservoir. Rule curves are presented in the Biological Assessment, Appendix E, in USACE (2000) for each project, and updated rule curves are included as Appendix C of this Opinion.[13] The function of the rule curve is to show how much storage space a reservoir should reserve for flood control at any given time of the year. There are three defined control periods in a year: flood control, conservation storage, and conservation holding and release.

Conservation storage means storing water for later use, not for environmental protection. The dates of these seasons vary slightly by project. The USACE is responsible for the daily regulation of all 13 dams, and for coordination with other Federal agencies, such as BPA. During wet winter conditions, when flood control is the primary authorized purpose, coordination with BPA can occur as frequently as once a week, and, at times, coordination can occur several times a day.

Each project is drawn down, as noted earlier, according to a prioritization system based primarily on hydrologic flood control and recreational needs. System drawdown priorities, as well as individual project priorities, are presented above in Table 2-6.

The Willamette Project is operated in conjunction with the Columbia River Basin Project to provide power to the Northwest power grid system. Generally, power production in the Willamette Basin is not adjusted directly to compensate for power shortfalls elsewhere within the system, except insofar as individual projects are operated under a load-following schedule to meet additional power demands within the Willamette Basin and nearby areas.

2.3.9 Land Use Management

Within the Willamette Basin, the USACE administers over 30,000 acres of Project lands. The USACE Regulation 1130-2-435 directs that the land use classifications for project lands be consistent with project land allocations. A project land's "allocation" identifies and documents the specific or generally authorized purposes for which the land was acquired. USACE lands are further classified based on their highest and best uses. The process of zoning the project area into land use classifications represents a further distribution of management categories which, based on the resource available and public need, would allow for full use while protecting project resources. USACE land use classifications define resource management and development practices, which may be either appropriate or inappropriate for that parcel of land. There are five land use categories into which lands at USACE projects may be classified: Project Operations, Recreation, Mitigation, Environmental Sensitive Areas, and Multiple Resource Management. The last can be further subdivided into Low-Density Recreation Use, General Wildlife Management, Vegetative Management, Inactive and/or Future Recreation Areas, and Easement Lands. The extent (acreage) of these lands on each of the projects is summarized in Table 3-13 of the BA (USACE 2000).

2.3.10 Bank Protection Program

The Flood Control Acts of 1936, 1938, and 1950 authorized the Willamette River Bank Protection Program and allowed the USACE to construct and maintain 450,000 linear feet of

[13] The rule curve for Foster Reservoir shown in USACE 2000 does not reflect current spill operations at Foster that were initiated subsequent to 2000. However, this information, as well as rule information for all projects, is included as an MS Excel spreadsheet in Appendix C.

protection works (USACE 2000). The program acts to prevent bank erosion, which affects farmland, roads, bridges, and other improvements. In 1971, the Senate and House Committees on Public Works expanded the program's scope to 510,000 linear feet. The Water Resources Development Act (WRDA) of 1950 required local sponsorship for any new bank protection projects, and it transferred responsibility for maintenance of revetments constructed after 1950 from the USACE to the local sponsor. Maintenance activities include vegetation control among revetment structures, which in the past has included the application of herbicides. However, in recent years, the USACE's inspection letters to sponsors have not required vegetation removal (USACE 2000).

The USACE has constructed or authorized construction of about 489,800 linear feet of erosion protection at 230 locations in the system. These projects are commonly rock revetments constructed of heavy quarry stone (riprap) placed on river banks to keep them from being eroded by the force of flowing water, wind, or wave action. Bank protection structures below RM 59.6[14] (near Dayton) are not part of the Willamette Project and are not maintained by the USACE.

2.3.11 Emergency Assistance Program

Willamette Project operations are must comply with by the Emergency Assistance Program under Public Law 84-99. Table 2-12 in USACE (2000) lists the variety of activities and types of assistance that the USACE may provide in association with flood control and bank protection works. Activities that most directly influence listed species include assisting with emergency bank reconstruction work, and preparation for anticipated, unusually large flood events.

2.3.12 Fish Conservation

The Flood Control Act of 1950 references a USACE report, HD 531, that recognizes the huge runs of anadromous fish in the Willamette River system before the project dams were built. HD 531 states that the dams will adversely affect anadromous fish, and that mitigation is needed. The USACE stated in the report that until passage is feasible, hatcheries are mitigation that should be used for these dams, effects on blocking passage for anadromous fish. More recently, section 306 of the Water Resources and Development Act of 1990 states that environmental protection is one of the USACE's primary missions in planning, constructing, operating and maintaining water resources projects.

2.4 The 2007 Supplemental Biological Assessment

The Action Agencies updated their 2000 Biological Opinion in 2007, specifically noting:

> "the intent of the Supplemental BA is not to replace the 2000 BA, but to provide information on the changes influencing the consultation since the 2000 BA was completed; hence, it is not intended as a stand alone document. Unless otherwise stated the elements of the revised proposed action supplement the proposed action

[14] Roughly, north of about McMinnville

described in the 2000 BA; the base operation for the Willamette Project to meet authorized purposes remains in place." (USACE 2007a)

NMFS has attempted to combine these two large documents and present a single Proposed Action that summarizes continued Project purposes and operations described in the 2000 BA as well as new actions proposed in the 2007 Supplemental BA. The Supplemental BA is organized by the following categories:

Continuing Coordination & Management (USACE 2007a)
This section proposes implementation of a regional forum called the Willamette Action Team for Ecosystem Restoration (WATER) and other related mechanisms to coordinate operation of the Willamette Project and implementation of ESA and related conservation measures between the Action Agencies, the Services, and other agencies and entities with water resource management and fish and wildlife responsibilities in the Willamette Basin.

***Project* Plans** (USACE 2007a)
This section provides an updated description of routine activities associated with operation and maintenance (O&M) of fish collection and handling facilities and presents a proposal for preparing an annual management plan for the facilities in coordination with the Services and ODFW. It also describes routine and non-routine activities associated with outages of turbines and regulating outlets that may have significant implications for aquatic species and habitat, and proposes mechanisms for coordinating with the Services in the event of their occurrence.

Flow Management (USACE 200a)
This section describes changes to reservoir storage and downstream flow timing and volume implemented subsequent to the 2000 BA (USACE 2000) including mainstem and tributary minimum flow objectives and ramping rate guidelines.

Hatchery Operations & Reform Actions (USACE 2007a)
This section describes the operation of the five hatcheries in the Willamette Basin that were constructed and are at least partially funded by the Action Agencies as mitigation for impacts of the construction of the Willamette Project. Measures to reform operation of the hatcheries to better meet the needs of ESA-listed are proposed by the Action Agencies.

Habitat Restoration & Management Actions (USACE 2007a)
This section describes current and proposed actions for restoring degraded habitat utilized by ESA-listed species both onsite (on-project) and offsite (downstream of project lands). This includes measures to address restoration of habitat associated with the Willamette Bank Protection Program.

Structural Modifications: Fish Passage, Temperature Control & Hatcheries (USACE 2007a*)*
The Action Agencies propose to undertake a series of studies to evaluate the feasibility of large-scale structural modifications; where shown to be technically feasible, biologically justified and cost-effective, the Action Agencies would seek authorization and funding needed to implement those measures.

Water Quality Improvements (USACE 2007a)
The Action Agencies propose to coordinate with the Services, U.S. Environmental Protection Agency (USEPA), ODFW, and Oregon Department of Environmental Quality (ODEQ) to develop and implement a Water Quality Management Plan (WQMP) that describes how the projects would be operated to better meet key water quality requirements for ESA-listed species consistent with Total Maximum Daily Loads (TMDLs) for temperature and total dissolved gas (TDG) developed by ODEQ in compliance with the Clean Water Act (CWA). The Action Agencies propose to operate the recently completed Cougar Dam water temperature control (WTC) facility to better meet downstream water temperature requirements of ESA-listed species. Cougar Dam is the only dam in the Willamette Project with selective withdrawal capability necessary to manage temperatures. The Action Agencies also propose to undertake an extended research, monitoring, and evaluation (RM&E) program associated with Cougar Dam. Evaluation of the physical and biological outputs associated with the Cougar Dam facility are critical to the decision-process associated with the potential for structural modification of other dams in the system.

Research, Monitoring & Evaluation Program (USACE 2007a)
The RM&E activities are integrated throughout the various elements of the proposed actions described in this chapter. Effectiveness monitoring and evaluation is critical for implementing and adaptively managing activities and measures associated with flow management, habitat restoration, hatchery operations and water quality improvements. In addition, rigorous RM&E efforts of existing baseline and possible future habitat and ESA population conditions under a range of potential structural and operational alternatives would be required to determine the feasibility of those alternatives. A mechanism for developing an integrated comprehensive RM&E program in coordination with the Services and others is proposed.

Contract Water Marketing Program (USACE 2007a)
The USACE and Reclamation propose to continue marketing irrigation water supply storage program with interim limitations to the amount of storage to be contracted and with proposed revisions water storage contracts designed to protect ESA-listed species.

Table 2-7 presents a summary of the revised Proposed Action, including current status and key milestones for implementation.

2.5. TERM OF PROPOSED ACTION

The 2000 BA (USACE 2000) presented the Proposed Action with no end date. The Action Agencies anticipated that the revised Proposed Action presented in this Supplemental BA would also continue for the life of the Willamette Project. Subsequently, the Action Agencies requested that the Services issue their Biological Opinions for a term of "at least 15" years (USACE 2007a), based on the following unique aspects of the Proposed Action: (1) availability of program funds appropriated by Congress or provided by others; (2) completion of more detailed evaluation to determine the feasibility of implementation of significant structural or operational modifications; and (3) continued RM&E needed for adaptive management-based decisions for implementation. Consequently, the Action Agencies recognize that there is a significant uncertainty associated with their ability to implement many elements of the supplemental proposed action, specifics of the mitigation measures, and the potential implementation time frame. Wherever possible, the Action Agencies attempted to define key steps or milestones in the individual actions to be used by the Action Agencies and the Services to determine relative progress toward implementation.

Table 2-7. Summary of Revised Proposed Action, Based on Willamette BA (USACE 2000) and Supplemental BA, Table 3-1 (USACE 2007a).

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
	Base project operation described in 2000 BA (USACE 2000) remains in place unless otherwise specified.	Ongoing Operation & Maintenance	Ongoing
2.6	**Continuing Coordination and Management**		
	Establish a formalized collaborative regional forum (WATER) for coordination of ESA activities.	Ongoing on an ad hoc basis through ESA Manager's Forum, Interagency Flow management Work Group, and Steelhead and Chinook Above Barriers (SCAB) Committee.	Establish charter and implement forum within 1 year of completion of the Opinion.
2.7	**Project Plans**		
	Describes routine and non-routine O&M activities for outages (turbine, regulating outlets & spillway gates)	Ongoing - occurs informally on an ad hoc basis through the Interagency Flow Management Work Group.	Ongoing
	Prepare Willamette Fish Passage and Management Plan: (1) identify optimal criteria for operating existing fish passage facilities; (2) describe scheduled and unscheduled maintenance of existing infrastructure that could impact listed fish; and (3) identify protocols for handling, sorting, and releasing fish collected a USACE-funded fish collection facilities. Updated annually; similar to Fish Passage Operations and Maintenance Committee process.	New action	Prepare plan within 2 months of completion of the Opinion.
2.8	**Flow Management**		
	Establish a formal Flow Management Committee under the WATER to coordinate and collaborate with the Services and other Federal, state, and tribal entities.	New, but occurs already through the interagency Flow Management Work Group.	Tied to WATER; establish charter within 1 year of completion of the Opinion.
	Establish a protocol for notifying Services of deviations from flow targets and related coordination.	Occurs informally.	Tied to WATER; establish charter within 1 year of completion of the Opinion.

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.8	Make every effort to meet or exceed minimum mainstem flow objectives as measured at Salem and Albany.	Occurs informally.	Existing targets; ongoing management activity.
	Make every effort to meet or exceed minimum tributary flows that ensure adult fish access to existing spawning habitat below USACE dams, protect eggs deposited during spawning, and provide rearing habitat for listed juvenile salmonids and other fish.	Occurs informally.	Existing targets; ongoing management activity.
	Adopt and follow specific hourly and daily ramp-down rates under normal operating conditions to reduce stranding and desiccation of juvenile fish, redds, and aquatic invertebrates resulting from unnatural flow fluctuations associated with operations of USACE dams.	Occurs informally.	Implement interim guidance immediately; complete a detailed Ramping Rate Study within 2 years of Opinion completion.
	Continue Foster Dam spring fish spill operation.	Occurs informally.	Existing operation; ongoing management activity.
	Flow-related research, monitoring, and evaluation (RM&E) program.	Partially ongoing at low level; future comprehensive RM&E funding contingent on obtaining funds from variety of sources.	Develop a comprehensive RM&E program within 12 months of completion of Opinion; tied to WATER RM&E Committee to develop program.
2.9	**Contract Water Marketing Program**		
	Reclamation and USACE propose to continue the existing irrigation water marketing program for the Willamette Project.	Ongoing marketing program	Continue immediately upon completion of consultation.
	No identified future cap on irrigation water marketing from the Project; water marketing of up to 95,000 acre-feet can be supported by current reservoir operations.	New action	
	In the event that future irrigation demand exceeds 95,000 acre-feet, Reclamation and USACE would reevaluate the availability of water from conservation storage for the water marketing program and consult with the Services.	New action	
	New form of long-term contract to specify ESA protections	New action	

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.10	**Hatchery Operations and Reform Actions**		
	Hatchery facilities - continue to operate and maintain four spring Chinook hatcheries (Marion Forks, South Santiam, McKenzie, and Willamette) and associated collection facilities.	Ongoing activities with new goal (hatchery reform): combination of mitigation and conservation hatchery program to increase natural production.	Ongoing
	Hatchery facilities - (1) rebuild collection facilities (Minto, Foster, Dexter); (2) resolve outstanding infrastructure needs; (3) develop long-term hatchery maintenance plans; (3) complete Environmental Review Guide for Operations (ERGO) assessments.	New actions contingent on funding.	Initiate modification of Minto fish collection facility in FY 2008. Implementation of other modifications contingent on findings of system configuration evaluations.
	Hatchery operations - continue use of current broodstock - most suitable for conservation purposes.	Ongoing activities	Ongoing
	Hatchery operations - increase % wild fish in broodstock; (2) ensure broodstock collected throughout the run; (3) insert coded wire tags into all releases in addition to adipose fin clip and otolith mark to ensure prompt ID of hatchery fish and mechanical sorting; (4) experimental release of smaller fish at Marion Forks to mimic natural life history pattern.	New actions	Initiate in FY 2008 pending increase in hatchery monitoring budget.
	Spring Chinook Reintroduction/Outplant Program – Goal is to increase natural production and increase availability of natural-origin fish for broodstock. Methods: (1) continue to release spring Chinook into habitat upstream of Detroit, Foster, Cougar, Lookout Point, and Hills Creek dams; (2) use new protocols for collection, handling, transporting, and releasing fish to increase likelihood of successful spawning; (3) work with USFS and BLM to develop suitable release sites; (4) protocols updated annually by Fish Passage and Hatchery Management Committee and included in Willamette Fish Passage and Management Plan; attached to Hatchery and Genetic Management Plans.	Ongoing activities coordinated through the ad hoc SCAB Committee. Future evaluation and implementation would be integrated into the system configuration feasibility studies.	Potential Columbia River Fish Mitigation (CRFM) funds for studies: RM&E critical to adaptively manage the program with co-managers.

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.10	Reducing straying of hatchery-origin McKenzie spring Chinook; evaluate options for constructing a trap at Leaburg Dam; combine with other efforts (including reducing mitigation production).	New action	Timing uncertain; would require coordination through EWEB and others.
	Summer steelhead: segregated program (minimize interactions with wild winter steelhead).		
	Continue use of South Santiam non-native summer steelhead.		
	Primarily RM&E to evaluate impacts (effectiveness of natural spawners, competition hatchery vs. natural origin juveniles); consider reductions in some subbasins.		
	Rainbow trout - relatively minor ESA-issues (other than how to meet production via water supply at Leaburg Hatchery).		
	Hatchery-related RM&E.		
	Genetic and life history characteristics monitoring.		
	Monitoring the conservation of wild/naturally spawning populations.		
	Reintroduction of spring Chinook into historic habitat.		
	Segregated hatchery program RM&E.		
	Habitat Restoration and Management Actions		
	Onsite habitat restoration and management activities: continue to use existing authorities and programs for land and water resource stewardship on USACE-administered lands to manage onsite habitat to benefit and protect ESA-listed species.	O&M environmental stewardship	Ongoing activities
	Offsite habitat restoration	CAP and GI are the only programs for offsite habitat restoration; strategic implementation with Services.	Some studies and construction ongoing; implementation of others is uncertain.

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.11	General Investigations (GI) Program: a. Willamette Floodplain Restoration Study b. Eugene/Springfield Metro Area Study c. Lower Willamette Ecosystem Restoration	GI (CG for implementation) Ongoing; complete by FY 2009. Ongoing; complete by FY 2010. Ongoing; complete by FY 2011.	Ongoing activities; implementation uncertain.
	Continuing Authorities Program (CAP): Sections 1135 and 206	Construction General (CG)	
	Willamette River Bank Protection Program: Comprehensive evaluation of habitat and biological impacts of revetments placed or funded by USACE bank protection program: (1) inventory and analyze; (2) identify sites where removal or modification may be feasible; (3) evaluate cumulative effects; (4) provide estimate of areas threatened by future erosion and bank protection; (5) procedures and criteria for justifying new bank protection projects; (6) identify and evaluate current and alternative measures; and (7) recommend and establish criteria for future bank protection and maintenance, repair and rehabilitation of existing sites.	New action	FY 2008 pending availability of funds
	Implement future bank protection modification or removal projects.	New action	Uncertain; implementation may occur through ongoing or future CAP/GI efforts.
	Habitat restoration RM&E.	Partially ongoing	Integrated into ongoing GI, CAP and Willamette Bank Protection Program measures (offsite) and/or O&M stewardship (onsite).
Section	**Summary of Revised Proposed Action**	**Current Status**	**Milestones/ Implementation Schedule**
2.12	**Structural Modifications: Fish Passage, Temperature Control and Hatcheries**		
2.12.1	Complete Post-authorization Change (PAC) report for the Willamette River Temperature Control Project.	Ongoing	FY 2007 ongoing

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
	Implement PAC report recommendations: (1) add fish passage facilities at Cougar; (2) undertake detailed post-construction monitoring and evaluation program.	Willamette Temperature Control Project	Initiate implementation FY 2008
2.12.2	Upgrade Minto Fish Collection and Handling Facility	New action	Complete Detailed Design Report (DDR) in FY 2008; P&S in FY 2009; Implementation in FY 2010.
	Work with the Services and ODFW to establish priorities and implement upgrades to remaining fish collection and handling facilities	New action	Integrate decision process into System Configuration studies.
2.12.3	System Review Feasibility Studies: Undertake a series of studies looking comprehensively at the entire basin and then systematically at the key subbasins to evaluate the feasibility and relative benefits of structural and related operational modifications to the Willamette dams designed to improve survival and productivity of ESA-listed aquatic species. Collectively called the System Review Study, these studies would include evaluation of: (1) the technical feasibility; (2) biological justification; and (3) cost-effectiveness of these and other potential measures so that the relative effectiveness and efficiency of potential Federal actions can be compared. In addition to addressing ESA, System Review would also address structural and operational needs associated with CWA compliance. The studies would be conducted in close coordination with the Services and other state/Federal agencies and tribes. The studies would result in decision documents stating agency positions on individual measures. For those measures determined to be feasible and recommended, the Action Agencies would seek authorization and funds for implementation through normal budget and program procedures.	New action	
2.12.3	Phase I: Reconnaissance	New action	Reconnaissance in FY 2008; $750,000

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.12.3	Phase II: Comprehensive Overview Systemwide Feasibility Study	New action	FY 2009 and outyears; Program CRFM
	Phase III: Detailed Subbasin System Configuration Studies	New action	Uncertain depending on funds. Goal is to complete the first Phase III study with Decision Document by FY 2011.
	Phase IV: Pre-construction Engineering and Design	New action	Uncertain depending on funds. Goal is to complete the first Phase IV study with Decision Document by FY 2012.
	Phase V: Implementation	New action	Uncertain depending on funds. Goal is to initiate construction of first Phase V project by FY 2013.
	RM&E for Structural Modification		Integrated into studies at Feasibility level per ER 1105-2-100.
2.12.4	Construction Activities Environmental Coordination and Management: Establish a WATER Technical Committee to coordinate construction activities based on Cougar Environmental Coordinating Committee (ECC).		Tied to WATER; establish charter within 1 year of completion of Opinion.
	Adopt Best Management Practices (BMPs) for construction of all structural modifications to the dams and assoc. facilities, including fish collection and handling, fish passage improvements, and water temperature control (WTC) implemented to improve conditions for ESA-listed species.		Patterned on BMPs established and followed for Cougar Temperature Control Project implementation.
2.13	**Water Quality Improvements**		
2.13.1	Cougar Dam WTC Project: Continue to operate the Cougar WTC Project to meet downstream temperature targets for protection of Chinook salmon.	Ongoing	Ongoing

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
2.13.1	Provide an extended biological RM&E program for Cougar WTC. The RM&E program would include effects of the WTC operation on downstream ecosystem and fish entrainment in the tower. Program objectives are to determine most effective protocols to implement WTC and trap-and-haul program, and to document the biological benefits realized from these protective and restorative measures.	Ongoing and new action	Initiate in FY 2008
	Develop a Cougar WTC Monitoring and Evaluation Plan in coordination with the Services and other members of the Cougar ECC.	New action	Complete by FY 2008
2.13.2	TMDL Water Quality Management Plan (WQMP): Coordinate with the Services and ODEQ, and USEPA to prepare a WQMP to address the TMDL for temperature and other water quality parameters consistent with the needs of ESA-listed species.	New action	Develop plan in FY 2008
	Participate in an Interagency Management Process for temperature-related improvements in Willamette Basin.	New action	Integrated into WATER's Water Quality/Temperature Control Committee
	Assist with collection and analysis of data necessary to support ODEQ revisions of load allocations for each of the 13 dams and reservoirs.	New action	Develop plan in FY 2008; implementation in FY 2009 and outyears in conjunction with specific projects.
	Demonstrate compliance and consistency with the Opinion for the Willamette Project.	New action	Develop plan in FY 2008; implementation in FY 2009 and outyears in conjunction with specific projects.
	Develop a temperature management plan to show temperature improvements needed to achieve load allocations.	New action	Develop plan in FY 2008; implementation in FY 2009 and outyears in conjunction with specific projects.

Section, as numbered in this Opinion, Chapter 2	Summary of Revised Proposed Action	Current Status	Milestones/ Implementation Schedule
	Develop a data and information strategy that may be used for future Use Attainability Analyses for the dams.	New action	Develop plan in FY 2008; implementation in FY 2009 and outyears in conjunction with specific projects.
2.13.3	Ongoing water quality RM&E program.	Ongoing action	Ongoing
	Future water quality RM&E program.	New action	
	Develop/implement multi-year water quality RM&E plan		
2.13.3	Develop/implement Water Temperature study		
	Develop/implement total dissolved gas monitoring plan.		
2.14	**Research, Monitoring and Evaluation Program**		
	Collaborate closely with the Services, ODFW, and others in developing and managing the comprehensive Willamette Basin RM&E program. The coordinating mechanism is the WATER Research Monitoring and Evaluation Committee.	New action	Develop the RM&E program in FY 2008; implement beginning in FY 2009.
	Guiding principles and Strategic questions		

2.6 CONTINUING COORDINATION & MANAGEMENT

This section summarizes existing and proposed mechanisms for continuing coordination and consultation in regard to ESA-listed species and related resource issues in the Willamette Basin.

Proposed Action: The Action Agencies would establish a formalized, collaborative body to assist in the coordinated implementation of the ecosystem restoration measures described in this revised proposed action.

Within 1 year of the completion of the Supplemental BA (USACE 2007a), the Action Agencies, in coordination with the Services and other Federal and state agencies and tribes with fisheries and water resource management responsibilities in the Willamette River Basin, would develop and implement a Charter for a collaborative body to be known at the Willamette Action Team for Ecosystem Restoration (WATER).

The basic purpose and goals of WATER would be to:

- Facilitate a long-term partnership among the Action Agencies and the Services for implementation of measures for recovery of ESA-listed species.
- Provide a forum for coordination and decision-making among the sovereign governments (Federal/state/tribal) working to implement strategies for ESA compliance and related missions and authorities, including Clean Water Act (CWA) compliance associated with the 13 Federal dams operated and maintained by the USACE in the Willamette River Basin.
- Provide an opportunity for input and thorough discussion amongst the Federal and state agencies and tribes actively engaged in these efforts.
- Increase the transparency of decisions on operation and configuration of the Willamette Basin dams as they relate to ESA and CWA compliance.
- Clearly define decision authority and provide a vehicle for elevating decision-making and conflict resolution associated with those efforts to appropriate levels of the involved governmental bodies.

The details of WATER would be worked out during development of the Charter. The Action Agencies initially propose that WATER would follow the hierarchical structure shown in Figure 2-3, below. The suggested structure is discussed in the following sections.

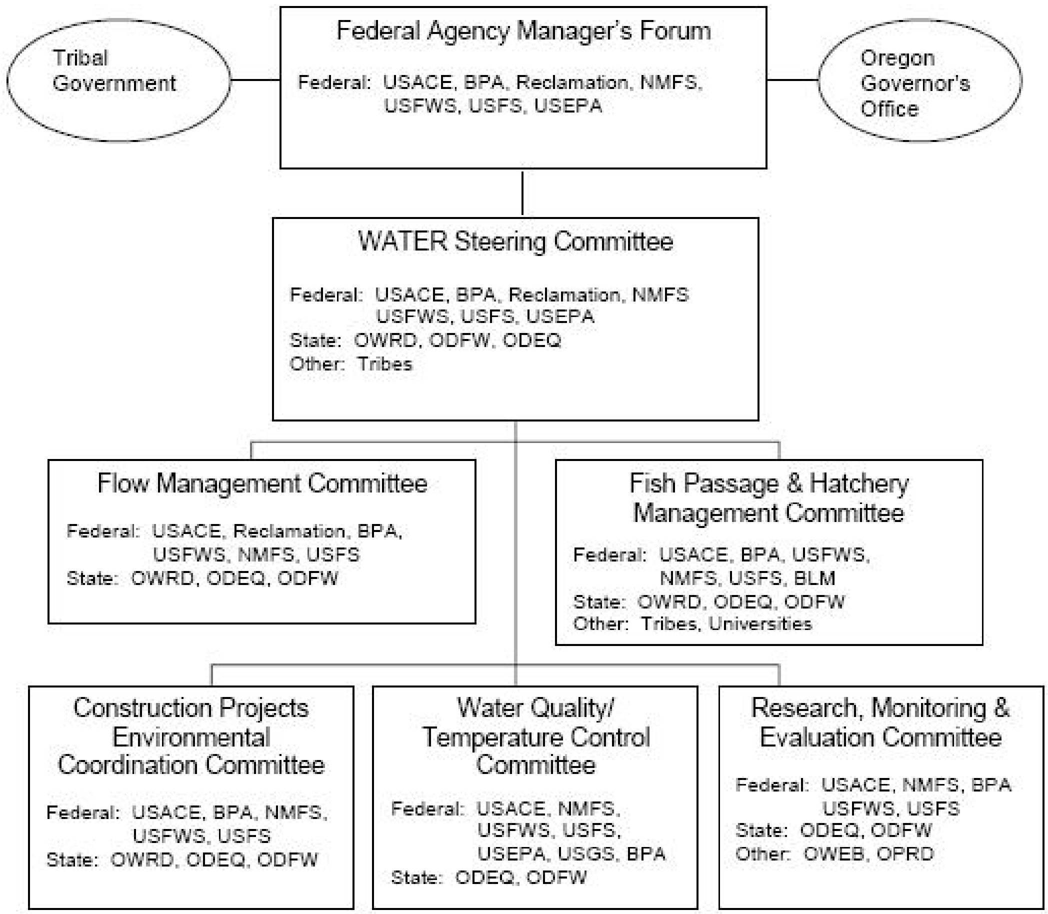

Figure 2-3 Proposed Organizational Structure, Willamette Action Team for Ecosystem Restoration (USACE 2007a).

2.6.1 Federal Agency Manager's Forum

This group would evolve from the existing Manager's Forum established to provide Federal agency senior management level oversight to the Willamette Project ESA consultation. The Forum would act as a regional policy and management level body representing the key participating Federal agencies with responsibility for operating and maintaining the Federal dams in the Willamette Basin (USACE, Reclamation, BPA), and implementation and compliance with ESA (the Services). The existing Forum would be expanded to include Federal agencies with responsibility for CWA compliance USEPA), and other agencies with closely related land and water management responsibilities (USFS). While the Forum would be limited to Federal managers, they would coordinate with executives of the other governmental sovereigns (Oregon governor's office, tribal organizations), as needed. The Forum would meet infrequently (annually or less, or as-needed) at critical milestones, to establish or confirm priorities, or to resolve issues elevated from the WATER Steering Committee level.

2.6.2 WATER Steering Committee

The WATER Steering Committee would be composed of senior project and program managers representing the Federal agencies involved in the ESA Section 7 consultation for the Willamette Project, as well as other key Federal agencies with land and water resource management responsibilities critical to implementation of ESA measures. The Steering Committee would provide project management oversight. It would also be the level at which the participating entities would seek to resolve most disputes and conflicts. The Steering Committee would provide oversight to the work of the five technical coordinating committees (Figure 2-3 above) including establishing annual budget and work priorities. The Steering Committee would be responsible for overseeing and coordinating the activities of the technical coordinating committees engaged in implementation of the separable elements for ESA and CWA compliance and recovery.

2.6.3 WATER Technical Coordinating Committees

Five technical coordinating committees would be established to oversee implementation of the different elements of the proposed action and related resource management activities. The Steering Committee would provide oversight for the technical committees, but the technical committees are the level at which much of the detailed work of implementing ESA and CWA compliance activities would be staffed, planned, scoped, designed, and implemented.

The technical committees would be populated by key functional area technical experts from each of the involved Federal and state agencies and tribes including the Action Agencies, NMFS, USFWS and other key participants including other Federal agencies (USFS, USEPA, U.S. Geological Survey [USGS]), state agencies (ODFW, OWRD, ODEQ, and others), tribal organizations, and other entities. Experts from academia and consulting firms may also become engaged as members of the technical committees, as needed. The makeup of the committees would be reflective of the scope of their respective areas of responsibility.

The number, scope, and responsibilities of the technical committees would be established by the Action Agencies working in collaboration with the Services. The ultimate number, responsibilities, and scopes of the technical committees formed would be determined by the Action Agencies working with the Services through development of a charter for WATER.

2.6.4 Flow Management Committee

The Flow Management (FM) Committee would evolve from the existing ad hoc interagency Flow Management Work Group that has been assisting the USACE in managing the operation of the Willamette Project since the 1990s. The function and responsibilities of the FM Committee are described in detail in Section 2.8.1. The FM Committee would be chaired by a representative of the USACE (Portland District Reservoir Regulation and Water Quality Section). Other members would include key Federal and state agencies with water management authorities and responsibilities in the Willamette Basin including the Services, BPA, Reclamation, USEPA, OWRD, ODEQ, and ODFW. The FM Committee would continue to act in an advisory capacity to the USACE, which would retain ultimate authority for operating reservoir elevations and downstream flows to meet authorized project purposes. However, more formalized rules, guidelines, and procedures would be established for ensuring that the agencies have adequate opportunity for providing input and coordination into flow management operations and for elevating and resolving disputes that may arise.

The FM Committee would meet frequently throughout the year including monthly meetings during the development and implementation of the annual conservation storage and release plan, and almost weekly (via conference calls) during real-time operations and would advise the USACE on the following tasks:

- Reviewing and evaluating reservoir operating criteria including mainstem and tributary flow targets, and revising operating manuals where appropriate.
- Designing and implementing flow monitoring and evaluation studies needed to determine the effects of reservoir operations on downstream habitat conditions, aquatic species, and water quality conditions.
- Developing the annual operating plan for the conservation storage and release season.
- Providing advice and consultation during real-time operations, particularly but not limited to the conservation storage and release season.
- Conducting annual reviews of Willamette Project operations and documenting issues, concerns and opportunities associated with improving operations to better meet ESA and CWA compliance requirements where possible.

2.6.5 Fish Passage & Hatchery Management Committee

Fish passage around several USACE dams currently uses hatchery collection facilities, and initial efforts to reestablish populations of salmon upstream of the dams involves the use of hatchery fish produced by USACE-funded hatcheries. Therefore, fish passage and hatchery-related issues would be addressed by one committee in the short term. The Fish Passage and Hatchery Management (FPHM) Committee would address issues related to fish passage at USACE dams, to ensure that operation of USACE-funded hatcheries minimizes impacts and supports recovery of ESA-listed species, and to coordinate reintroduction efforts in areas upstream of the dams. A major responsibility of the FPHM Committee would be to develop and annually update the Willamette Fish Passage and Management Plan (FPMP) as described in Section 3.2.2. The Action Agencies envision the FPHM Committee as an interagency team with similar organization and function as the Fish Passage Operations and Maintenance Team on the Columbia River.

The FPHM Committee would evaluate the results of fish passage and hatchery-related RM&E efforts (and refine RM&E efforts accordingly), as well as annually update the Willamette FPMP including broodstock collection protocols and disposition of hatchery- and natural-origin fish, based on the results of RM&E, run size predictions, or structural changes, such as new fish collection facilities, passage facilities, or WTC structures. Because all hatcheries funded by the Action Agencies are partially funded by the State of Oregon (via ODFW), the Action Agencies, and the State of Oregon are responsible for effective hatchery operation and monitoring. Thus, the FPHM Committee would serve as the forum for developing a thorough implementation plan for the hatchery monitoring program that specifies which RM&E tasks would be funded and/or carried out by the State of Oregon, the Action Agencies, or other entities.

2.6.6 Construction Projects Environmental Coordinating Committee

The Construction Projects Environmental Coordinating (CPEC) Committee would work to coordinate implementation of all future structural modifications undertaken at the Willamette dams to address ESA fish and related needs including fish collection and handling, fish passage, hatchery and WTC facilities. The roles and responsibilities of the CPEC Committee are described in Section 3.6.5. The Action Agencies envision the CPEC Committee as an interagency team with similar organization and function as the Environmental Coordination Committee (ECC) established for construction of the Cougar Dam WTC with NMFS, USFWS, and other key agencies and entities as members.

2.6.7 Water Quality/Temperature Control Committee

The primary responsibility of the Water Quality and Temperature Control (WQTC) Committee would be to ensure integration of water quality improvement requirements undertaken by the Action Agencies to address the needs of ESA-listed species with the requirements undertaken to address CWA requirements. In addition to the Action Agencies and Services, other key members of the WQTC Committee would include USEPA, USGS, and ODEQ.

Activities and responsibilities of the WQTC Committee may include:

- Assisting in the development of study plans for water quality RM&E.
- Assisting in development of uniform water quality criteria and standards for CWA and ESA compliance.
- Reviewing and evaluating water quality RM&E results.
- Assisting in development of criteria for prioritizing WTC proposals.
- Research, Monitoring and Evaluation Committee

The RM&E Committee would be established to oversee development and management of the Willamette RM&E program. In addition to the Action Agencies and Services, other participants of the RM&E Committee may include ODFW, USGS, USEPA, tribes, universities, and others. The Action Agencies foresee this committee overseeing an annual planning process for developing the Willamette RM&E program that is similar to the Federal Columbia River Power System (FCRPS) Regional Forum that develops and manages the USACE Anadromous Fish Evaluation Program. The RM&E Committee, consisting of technical representatives from each resource management agency, would function as a technical review group. This committee's role would be to identify RM&E needs and priorities, develop research summaries, provide peer review for research proposals and reports, and provide recommendations on ongoing and future actions based on research results. The RM&E Committee would be chaired by a USACE representative who would convene meetings, record minutes, and assures that action items are completed. Based on the recommendations of the RM&E Committee, the Action Agencies would solicit study proposals, oversee study completion, and facilitate peer review of study proposals and research reports to ensure results are based on sound science. Section 3.8 provides additional information regarding the RM&E Committee.

2.7 PROJECT PLANS

The Action Agencies propose the following project plans: (1) describe the kinds of routine scheduled and non-routine unscheduled maintenance activities associated with project operations; (2) outline the Willamette Fish Passage and Management Plan , which would thoroughly describe the operation of all USACE infrastructure that handles or impacts ESA-listed fish, including existing fish collection and passage; and (3) propose mechanisms for coordinating and consulting with the Services and other key stakeholders in the event that unscheduled outages occur.

2.7.1 Routine & Non-routine Operations & Maintenance Activities

Proposed Action: **The USACE would continue routine and non-routine maintenance at Project dams.**

Each calendar year turbine units, regulating outlets, and spillway gates at the Willamette Project are placed out of service for routine and non-routine maintenance. All turbine units are placed out of service for 1-2 weeks each year for annual maintenance. In almost all cases, this requires the units to be completely dewatered. The units are inspected, cleaned, and lubricated. Each unit is also on a rotating schedule for a more rigorous inspection and cavitation repair approximately every 5 years. This requires the unit to be completely dewatered and placed out of service for 4-8 weeks. In addition to routine maintenance, turbine units are placed out of service for non-routine maintenance. Each turbine unit undergoes a unit rewind every 25-50 years. Each rewind is about 5 months in duration. Turbine units may also be replaced every 25-50 years. Routine and non-routine maintenance on turbine units is always scheduled; however, each year turbine units and regulating outlets may malfunction or be placed out of service for an emergency which results in an unscheduled outage. Timing of these outages is unpredictable and the durations are uncertain.

2.7.2 Willamette Fish Passage & Management Plan

Proposed Action: **To minimize impacts to listed fish in the Willamette Basin resulting from the operations and maintenance of the existing infrastructure, the Action Agencies would develop a Willamette Fish Passage and Management Plan within 2 months of the completion of the Willamette Project Biological Opinion.**

The Willamette FPMP would: (1) identify optimal criteria for operating fish passage facilities while still meeting authorized project purposes; (2) describe scheduled and unscheduled maintenance of existing infrastructure that could potentially negatively impact listed fish; and (3) identify protocols for handling, sorting, and releasing fish collected at USACE- funded fish collection facilities. The FPMP would also describe mechanisms and procedures for coordinating and consulting with Federal and state resource agencies in the event of scheduled or unscheduled maintenance. With guidance from the WATER FPHM Committee, USACE would update the FPMP annually to provide ODFW and USACE operators and managers with clear guidance on how to operate each facility. The FPMP would clearly identify the number, origin, and species of fish to be released into habitat upstream of USACE dams, incorporated into the hatchery broodstock, or taken to other destinations. Annual updates would be based on results of RM&E activities, construction of new facilities, recovery planning guidance, predicted annual run size, and changes in hatchery management. The Willamette FPMP would generally follow the draft outline and the "example" section provided in Appendix A of the Supplemental Biological Assessment, (USACE 2007a) Outline of Fish Passage and Management Plan.

2.8 Flow Management Measures

Proposed Action: **The Action Agencies would manage water storage and releases at the Willamette Project to avoid or minimize adverse effects on listed fish species by carrying out the following measures:**

2.8.1 WATER Flow Management Committee

The Action Agencies would establish a formal Flow Management Committee under WATER to coordinate and collaborate with the Services and with other Federal, state, and tribal entities in the operation of the Willamette reservoirs and in the implementation of measures in Sections 2.8.2 through 2.8.7 (min mainstem flows thru RME below). The USACE would take a leadership role in the administration of this committee, providing for coordination, administration costs, and meeting space. The committee would serve the purpose of providing for development and implementation of the annual Willamette Conservation Plan (WCP), including continued coordination with the Services and with other official agencies and entities throughout the flow management season.

2.8.2 Protocol for Notification of Deviations

The Action Agencies would notify members of the FM Committee by e-mail or phone if conditions or circumstances (e.g., flood damage reduction, emergency operating conditions, etc) might result in deviations from measures in Sections 2.8.3, 2.8.4, 2.8.5, or 2.8.6 (minimum mainstem flows, tributary flows, ramping rates, Foster spill below). If the FM Committee is not e-mailed prior to the deviation event, the USACE would notify the Services within 48 hours of the action taken and would coordinate with the Services within 30 days thereafter. A brief summary report explaining the action taken and the circumstances requiring it would be prepared within the 30-day period following the action. This approach would be taken only if it is not possible to coordinate with the FM Committee or the Services prior to the event.

2.8.3 Minimum Mainstem Flows

The Action Agencies would operate the Project to make every effort to meet or exceed minimum mainstem flow objectives (Table 2-8 below USACE 2007a Table 3-2) as measured at Salem and Albany, Oregon, during April through October in abundant and adequate flow years following the framework described in Appendix D of this Opinion (USACE 2007, Appendix B) and in collaboration with the Services and other official parties as indicated under Section 2.6.4, the WATER Flow Management Committee. Reduced flow targets would be met in drier years (USACE 2007a, Appendix B).

The flow objectives in Table 2-8 below (USACE 2007a Table 3-2) combine the statutorily authorized minimum flows (House Document 531) as measured at Albany and Salem for the June through October period, which guided historical operations, with new mainstem "fish flow" objectives for April through June. The June through October mainstem flow objectives were described in the Action Agencies' original BA (USACE 2000). The spring targets were added in the 2007 Supplemental BA (USACE 2007a), even though the USACE first began using them in 2000 and have treated them as primary operating criteria since then.

Table 2-8 Mainstem Willamette Flow Objectives (USACE 2007a Table 3-2).

Time Period	7-Day Moving Average[1] Minimum Flow at Salem (cfs)	Instantaneous Minimum Flow at Salem (cfs)	Minimum Flow at Albany (cfs) [2]
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500
June 16 - 30	8,700	7,000	4,500
July 1 - 31	---	6,000	4,500
August 1 - 15	---	6,000	5,000
August 16 - 31	---	6,500	5,000
September 1 - 30	---	7,000	5,000
October 1 - 31	---	7,000	5,000

[1] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.
[2] Generally, Congressionally authorized minimum flows (House Document 531). September flows were extended into October.

The flow management protocol described in Appendix D of this Opinion (USACE 2007a, Appendix B) characterizes available flow and water storage during each flow year as "abundant," "adequate," "insufficient" or "deficit" based on the forecasted system-wide storage available by mid-May (Table 2-9, USACE 2007a Table 3-3). The frequency of occurrence for each type of flow year was calculated over the 66-year period of record from 1936-2001 (USACE 2007a, Appendix C).

The "insufficient" threshold volume is based on results of water management actions implemented in 2001 to carefully balance risks associated with the multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species. Attempts to balance these concerns were not previously undertaken in drier years. The "deficit" years would require diligent evaluations of flow management alternatives and coordination during development of the annual Willamette Conservation Plan (page 41) CP using adaptive management. Reservoir-specific draft limits would be used throughout the flow management season in "insufficient" and in "deficit" years to balance flows among tributaries and to avoid loss of all the usable storage and control of minimum flow discharge below any one project.

Table 2-9 Characterization and Historic Frequency (N=64; 1936-1999) of Water Year Types in the Willamette River Basin (USACE 2007a Table 3-3).

Characteristics of Water Year Types	Abundant	Adequate	Insufficient	Deficit
Mid-May storage (MAF)[1]	≥ 1.48	1.20 to 1.47	0.90 to 1.19	< 0.90
Frequency	58%	17%	9%	16%
Meet all mainstem flow objectives?	Yes	Yes	No	No
Alternative flow targets below objectives	N/A	N/A	Linear sliding scale based on flow targets used during 2001 water year [2]	Balance seasonal flows to retain some control of discharge [2]
Likely status of priority recreational reservoirs[3]	Full throughout most or all of recreation season	Full through most of recreation season	May fill; unlikely to remain full throughout season	Unlikely to fill
Likely Status of Other Reservoirs	Likely to fill; drafted as necessary to meet mainstem flows	May fill; unlikely to remain full throughout season	Unlikely to fill	Unlikely to fill

1 Forecasted useable system-wide reservoir storage accumulated by May 10-20 in millions of acre-feet (MAF).

2 Reservoir-specific draft limits would be used to ensure projects can meet minimum flows through the fall.

3 Detroit, Fern Ridge, and Foster are considered the high-priority reservoirs. "Full" designation means that the project is at an acceptable level for recreation, but physically may not be at maximum conservation pool, or normal summer levels.

2.8.4 Minimum & Maximum Tributary Flows

The Action Agencies would operate to make every effort to meet or exceed minimum tributary flows (Table 2-10 USACE 2007a Table 3-4) depending upon available storage and inflow into each of the associated reservoirs and consistent with flood damage reduction and public safety requirements. The Action Agencies would make every effort to meet or exceed these minimum flows to ensure adult fish access to existing spawning habitat below USACE dams, protect eggs deposited during spawning, and provide rearing habitat for listed juvenile salmonids and other fishes. During winter steelhead and spring Chinook salmon spawning seasons, the Action Agencies would make every effort to maintain flows below the specified maximum flow rate (also in Table 2-10) under normal operating conditions. Because the Action Agencies do not consider "flood damage reduction actions" as "normal operating conditions," the maximum flows listed in Table 2-10 may be exceeded during flood damage reduction operations.

Table 2-10 Minimum and Maximum Tributary Flow Objectives Below Willamette Dams (Donner 2008).

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
Hills Creek	Sep 1 - Jan 31	Migration &	400	99.9		
	Feb 1 - Aug 31	Rearing	400	99.9		
Fall Creek	Sep 1 - Oct 15	Chinook spawning	200	95	400 through Sep 30, when possible	25
	Oct 16 - Jan 31	Chinook	50 [3]	99.9		
	Feb 1 - Mar 31	Rearing	50	99.9		
	Apr 1 - May	Rearing	80	99.9		
	Jun 1 - Jun 30	Rearing/adult	80	99.9		
	Jul 1 - Aug 31	Rearing	80	95		
Dexter	Sep 1 - Oct 15	Chinook spawning	1200	99.9	3,500 through Sep 30, when possible	10
	Oct 16 - Jan 31	Chinook	1200 [3]	99.9		
	Feb 1 - June	Rearing	1200	99.9		
	Jul 1 - Aug 31	Rearing	1200	99.9		
Big Cliff	Sep 1 - Oct 15	Chinook spawning	1500	95	3,000 through Sep 30, when possible	5
	Oct 16 - Jan 31	Chinook	1200 [3]	98		
	Feb 1 - Mar 15	Rearing/adult	1000	99.9		
	Mar 16 - May	steelhead	1500	99.9	3,000	25
	Jun 1 – Jul 15	steelhead	1200 [3]	99.9		

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED [4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
	Jul 16 - Aug	Rearing	1000	99.9		
Foster	Sep 1 - Oct 15	Chinook spawning	1500	75	3,000 through Sep 30, when possible	1
	Oct 16 - Jan 31	Chinook	1100 [3]	80		
	Feb 1 - Mar 15	Rearing	800	95		
	Mar 16 - May	steelhead	1500	80	3,000	30
	May 16 - Jun	steelhead	1100 [3]	95		
	Jul 1 - Aug 31	Rearing	800	99		
Blue River	Sep 1 - Oct 15	Chinook spawning	50	99.9		
	Oct 16 - Jan 31	Chinook	50	99.9		
	Feb 1 - Aug 31	Rearing	50	99.9		
Cougar	Sep 1 - Oct 15	Chinook spawning	300	99.9	580 through Sep 30, when possible	60
	Oct 16 - Jan 31	Chinook	300	99.9		
	Feb 1 - May	Rearing	300	99.9		
	Jun 1 - Jun 30	Rearing/adult	400	99.9		
	Jul 1 - Jul 31	Rearing	300	99.9		
	Aug 1 - Aug	Rearing	300	99.9		

[1] When a reservoir is at or below minimum conservation pool elevation, the minimum outflow will equal inflow or the Congressionally authorized minimum flows, whichever is higher.

[2] Maximum flows are intended to minimize the potential for spawning to occur in stream areas that might subsequently be dewatered at the specified minimum flow during incubation.

[3] Incubation flows are intended to be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

[4] Flow duration estimates are based on HEC-ResSim model output data for the BiOp operation. Period of Record of model data is Water Years 1936-2004.

The Action Agencies would meet these tributary flow levels whenever sufficient water storage and inflow is available, subject to flood damage reduction operational demands. Hydraulic modeling and draft limits would be used (as described in Appendix D of this Opinion and in USACE 2007a, Appendix B) to adjust discharge rates to below the minimum flow levels in Table 2-10 when necessary to avoid depletion of reservoir storage and subsequent loss of ability to regulate flows. Note the "chance of not meeting flow" in Table 2-10 for an indication of the frequency with which the Action Agencies are likely to fall below these minimum flows based on the 66-year period of record from 1936-2001 (Donner 2008). These actions would be coordinated through the WATER FM Committee according to the protocol described in Section 2.8.1 above.

When reservoirs are operating for flood damage reduction, pools are held at or below the flood control rule curve. During winter flood operation season, this level is equivalent to the minimum conservation pool level. This means there is no stored water available for flow augmentation, and if inflow is less than the preferred minimum outflow levels depicted in Table 2-10, then outflow would equal inflow down to the project authorized minimum flows. The Action Agencies expect to be able to forecast and or evaluate the potential for these incidences relatively far in advance and would coordinate them through the FM Committee in accordance with Section 2.8.1 above.

Maximum flows during spawning periods would be observed depending on current and predicted levels of inflow, the elevation of each reservoir in relation to its rule curve, and the need to effectively manage high flow events that could result in flood damage. Likewise, the Action Agencies would attempt to manage flows during incubation periods to be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. The need to evacuate a reservoir in preparation for the flood damage reduction season, or to bring it back into compliance with its rule curve following storage of a high water event, is likely to result in discharges that are in excess of the maximums in Table 2-10. The frequency of historic exceedences over the 66-year period of record from 1936-2001 (USACE 2007a, Appendix C) is included in the last column of the table under "chance of not meeting flow." The Action Agencies would strive to keep these occurrences and their durations at a minimum, while continuing to provide for flood damage reduction, as necessary. Exceedences would be coordinated and reported in accordance with the protocol outlined under Section 2.8.1 above.

During spring and summer, hydrologic modeling of flows and storage in the Santiam River would be used to balance rates of discharge that occur during the winter steelhead spawning season with subsequent flows needed during the incubation period to protect natural production of winter steelhead. Use of storage would also consider, and balance with, the need to meet mainstem Willamette River minimum flow objectives and the need to meet minimum tributary flow objectives in the fall during the spring Chinook salmon spawning season.

The Action Agencies are less able to balance spawning period flows (approximately September 1 through October 15) and subsequent incubation period flows (currently through approximately January 31) during fall and winter to protect spring Chinook salmon. This is because the reservoirs are evacuated in September and October (often exceeding maximum spawning flow rates) prior to the onset of the flood damage reduction season, leaving little or no storage in reservoirs for use in maintaining incubation flows above levels of reservoir inflow. The Action Agencies would avoid unnecessarily high flows during the spawning season for spring Chinook salmon, especially through 30 September, as a means of reducing the risk of redd desiccation due to uncontrollably low flows during the subsequent incubation period. However, their ability to do so is limited by operational requirements associated with providing effective flood damage reduction capability.

2.8.5 Ramping Rates

The Action Agencies would adopt and follow specific hourly and daily ramp-down rates (Table 2-11) at Project dams whenever possible consistent with project purposes. The Action Agencies would use the ramping rates depicted in Table 2-11 for decreasing the flow levels below Willamette Project dams under normal operating conditions to reduce stranding and desiccation of juvenile fish, redds, and aquatic invertebrates resulting from unnatural flow fluctuations associated with operations of USACE dams. Because the Action Agencies do not consider "flood damage reduction actions" as "normal operating conditions," the ramping rates listed in Table 2-11 may be exceeded during flood damage reduction operations. The Action Agencies would work with the WATER FM Committee to plan and carry out studies to characterize channel configuration, ramping rates, flow-habitat relationships, and flow dynamics below Willamette Project dams. Those evaluations would be conducted in the context of the broader flow-related RM&E program described in Section 2.8.7 below.

Table 2-11 Maximum Ramping Rates During Flow Level Changes Below Upper Willamette Basin Dams (cfs) (USACE 2007a, Table 3-5).

Nighttime Rampdown Rates to Achieve 0.1 ft/hour [1, 2, 4, 6, 7]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	60 [3]	1500	125	100	20 [3]	100		300	30 [3]	500	80 [3]	250	30 [3]	80	20 [3]	900	100	1200	100
1000	75 [3]	2000	145	300	40 [3]	500	50 [3]	500	40 [3]	1200	100 [3]	500	50 [3]	150	30 [3]	1900	150	1500	110
1500	90 [3]	2500	150	500	50	1000	60 [3]	800	50	2400	150	700	60 [3]	300	40	2000	155	2000	130
1700	100	3000	170	700	60	3700	100					2300	100	1000	50				

Highlighted flows are higher than the minimum flows needed to protect ESA species, but are included to represent the lowest flow rate at which 0.1 ft/hr ramp rate is currently possible at these dams.

Daytime Rampdown Rates to Achieve 0.2 ft/hour [1, 2, 6, 7]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	120	1500	250	100	40 [3]	100		300	60	500	160	250	60 [3]	80	40	900	200	1200	200
1000	150	2000	290	300	80	500	100	500	80	1200	200	500	100	150	60	1900	300	1500	220
1500	180	2500	300	500	100	1000	120	800	100			700	120	300	80	2000	310	2000	260
		3000	340	700	120									1000	100				

[1] Avoid a flow volume reduction of more than 50% per hour or the lesser of 1 foot or 50% per 24 hours.

[2] Listed are decrements in release that approximately yield the resulting change in flow of 0.1 foot/hour or 0.2 foot/hour. The accuracy of any flow change is subject to the variability of the equipment and instrumentation.

[3] Small listed increments in flow are impractical to achieve under current equipment capability.

[4] From 1 January - 31 March a nighttime ramp is preferable. A rate of 0.2 ft/hour is considered acceptable for protecting juvenile spring Chinook salmon [NOTE: need to clarify w/Action Agencies].

[5] Higher priority because of the presence of ESA listed salmon and steelhead. When system operations prevent USACE from meeting rampdown rates at all projects, USACE will place priority on achieving ramp rates at these projects noted as high priority for fish protection.

[6] Change in flow at flows higher than those listed are less critical for protecting ESA species because of proportionally smaller flow volume change.

[7] Ramping rates listed are for reservoir operation other than when reducing project outflow to manage for downstream flood damage reduction.

The Action Agencies would not achieve prescribed ramping rates in instances where actual hydrologic conditions turn out to be significantly different from the forecasted conditions. For example, the rate of change in outflows may have to be accelerated to avoid dropping below the minimum pool elevation with a prolonged ramp-down if inflow drops off faster than expected following a storm event. This typically occurs during recessions following significant rain events that require evacuation of flood storage.

2.8.6 Foster Dam Spring Spill

The Action Agencies would continue the spring spill operation at Foster Dam, as described in Section 2.3.2.3 (Chapter 2-32) of the Action Agencies' 2000 BA (USACE 2000) without change. Under this operation, approximately 92 to 238 cfs (0.5 to 1.5 feet of water depth), depending upon reservoir elevation and inflow, would be spilled daily from 0600 through 2100 hours from April 15 through May 15 each year to facilitate passage of juvenile and kelt winter steelhead and juvenile spring Chinook salmon that may be passing from the reservoir near its surface.

2.8.7 Flow-related Research, Monitoring & Evaluation

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of the measures in Section 2.8. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and following the principles and strategic questions developed by the committee.

In the mainstem Willamette River and its major tributaries affected by USACE dams, the Action Agencies would plan and carry out studies to characterize functional relationships between anadromous fish migration and flows. These studies would focus on the aspects of fish distribution (e.g., habitat use) and behavior (e.g., migration timing) in relation to rates of discharge by time of year. The Action Agencies, in cooperation with the Services and with the FM Committee, would use this information to better inform and balance tributary and mainstem flow management. If warranted, the Action Agencies would modify, with the approval of the Services, the mainstem flow objectives presented in Table 2-8 (USACE 2007a, Table 3-2) based on relevant findings.

In the tributaries affected by USACE dams, the Action Agencies would plan and implement studies to characterize channel configuration, the effects of ramping, flow-habitat relationships, and flow dynamics below the Willamette dams. Where appropriate, the Action Agencies would experiment with a variety of flow management options (e.g., pulsed flows) that are intended to enhance normative ecosystem function and to restore or rejuvenate critical fish habitat (Gregory et al. 2007). This would include an evaluation of relationships between tributary flow rates and critical habitat for Oregon chub, especially under low flow conditions. The Action Agencies, in cooperation with the Services and with the FM Committee, would use information from these studies to better inform and balance tributary flow management, including minimum and maximum flow levels, ramping rates, and special actions (e.g., pulsed flows). The Action Agencies would also attempt to more clearly define the impacts of contractual irrigation and withdrawals on tributary flows. As a result of these studies, or if modeling indicates that tributary flow objectives are not physically feasible to achieve as proposed, the Action Agencies may modify, with the approval of the Services, the tributary flow objectives presented in Table 2-10 above or the ramping rates presented in Table 2-11 above (USACE 2007a, Table 3-5) based on relevant findings.

The Action Agencies do not currently have a clearly established source of funding available for implementing a comprehensive flow-related RM&E program. Funding would likely need to be derived from a variety of potential sources. The earliest that significant funding may be available for this program is FY 2010 (i.e., beginning September 1, 2009).

2.9 BUREAU OF RECLAMATION WATER MARKETING PROGRAM

Proposed Action: Reclamation and the USACE would continue the existing irrigation contract water marketing program for the Willamette Project. Reclamation would issue new contracts and maintain existing ones such that the total water marketing program would not exceed 95,000 acre-feet. Taking both existing contracts and pending contract applications into account, 14,569.33 acre-feet would remain available to meet future irrigation demands under the duration of the consultation. In the event that future irrigation demand exceeded 95,000 acre-feet, Reclamation and the USACE would reevaluate the availability of water from conservation storage for the water marketing program and consult with the Services.

Section 8 of the Flood Control Act of 1944 gave authority to the Secretary of the Interior to market water stored by Project dams. A series of letters exchanged during 1952 and 1953 constitute the agreement between Reclamation and the USACE that allows for the sale of water from the Willamette Project for irrigation purposes. Conservation storage space totaling 1,592,800 acre-feet is included in 11 of the 13 reservoirs. Reclamation received water right certificates from the OWRD to store water in the storage space allocated to irrigation. Irrigated agriculture in the Willamette Basin is used primarily in July to October for late maturing crops.

At present a total of 205 long-term water service contracts are in effect. Sixty-two percent (127 of 205) of existing contracts have been entered into since 1990. Although the largest contract can provide up to 9,625 acre-feet of water for the irrigation of 3,500 acres and several others contract for more than 1,000 acre-feet annually, most of the contracts serve smaller acreages to individual water users. Cumulatively, the 205 contracts can provide up to a maximum of 50,231 acre-feet of stored water for irrigation of 25,027 acres of land (USACE 2007a).

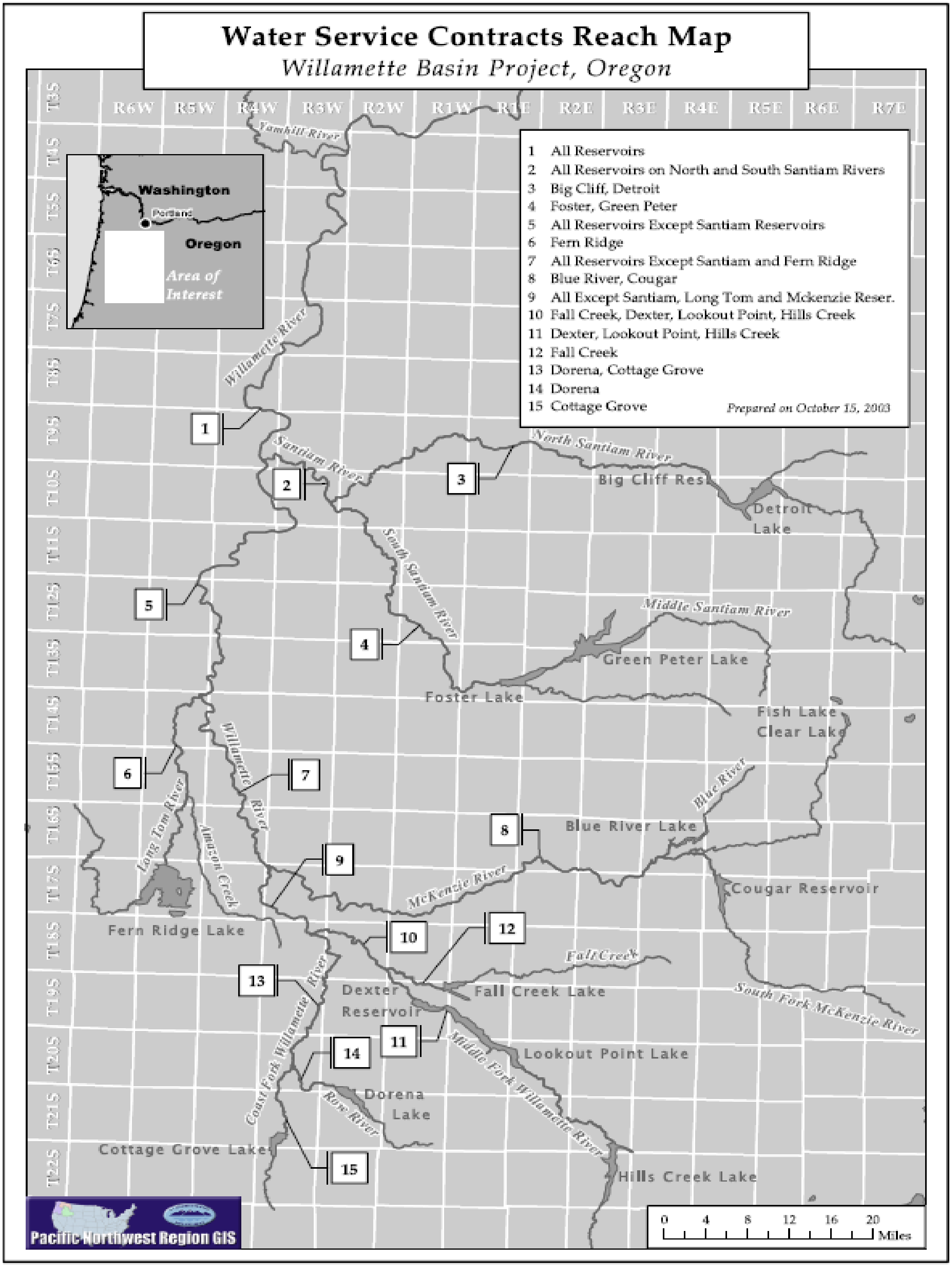

Figure 2-4 Water Service Contracts Reach Map, Willamette Basin (USACE 2007a Fig. 3-13).

Table 2-12 (USACE 2007a, Table 3-24) and the water service contracts reach map for the Willamette Basin, Figure 2-4 (USACE 2007a, Figure 3-13) identify the number of contracts and quantity of stored water provided under each of the 15 reaches downstream of USACE reservoirs. A list of the 205 existing contracts is found in USACE 2007a, Appendix D. In 1999, Reclamation estimated that 40% of the contracts provided stored water to be used as supplemental water on lands with primary natural flow and/or groundwater rights, while the remaining 60% were used as a primary source of water.

Subsequent to the initial listing of UWR Chinook salmon and UWR steelhead in 1999, Reclamation placed a moratorium on issuing new long-term contracts. In 2003, Reclamation lifted the moratorium, yet has not entered into any contracts with terms longer than 1 year.

Table 2-12 Storage Volumes Currently Under Contract for Irrigation Use (USACE 2007a Table 3-24).

Reach	Reservoir Providing Water	Number of Contractors	Total Acre-feet Contracted	Total Acres Served
Willamette River				
Downstream of Santiam River	All	28	6,760.05	3,544.44
Santiam River - Long Tom	All except Santiam Basin	15	3,631.39	1,842.62
Long Tom River - McKenzie	All except Santiam Basin	5	570.00	255.00
McKenzie River - Coast Fork	Fall Creek,	1	9.50	3.80
Long Tom River	Fern Ridge	58	24,052.875	9,876.55
Middle Fork Willamette River				
Downstream of Fall Creek	Fall Creek,	1	135.73	54.29
Fall Creek - Dexter	Dexter/Lookout Point,	2	92.00	36.80
Fall Creek	Fall Creek	2	12.50	5.00
Coast Fork Willamette River				
Middle Fork - Row River	Dorena, Cottage Grove	9	1,164.55	469.61
Row River - Cottage Grove	Cottage Grove	1	56.387	45.11
Row River	Dorena	1	51.00	20.40
McKenzie River	Blue River, Cougar	31	1,640.115	854.48
Santiam River to Forks	Detroit/Big Cliff, Green	7	1,485.05	1,646.60
North Santiam River	Detroit/Big Cliff	30	9,473.545	5,807.26
South Santiam River	Green Peter, Foster	14	1,096.11	564.68
TOTALS		**205**	**50,230.802**	**25,026.64**

As of March 2007, there were a total of 62 applications pending for water service from the project in the various stages of processing (a summary of applications per reach is included in USACE 2007a, Appendix D). These requests, if approved, would provide up to 30,200 acre-feet of stored water to irrigate 17,649 acres of land. Upon execution of these contracts, the water marketing program would include 267 active long-term contracts for the annual irrigation of 42,675 acres with up to 80,431 acre-feet of stored water; approximately 5 % of the active conservation storage space available in project reservoirs.[15] Table 2-13 (USACE 2007a, Table 3-25) identifies the number of existing and pending contracts, volume of stored water, and acreage served for each of the 15 reaches downstream of USACE dams.

At the current low level of use for water service contracts, the USACE does not make special operational adjustments, such as increasing flow releases, to meet contract requirements. The USACE does not propose to make special flow adjustments at its dams to supply the total water marketing program of 95,000 acre-feet during the term of this action.

Reclamation and the USACE propose to avoid potential impacts of water contracts on listed species through the USACE's ongoing reservoir management activities and through continued inclusion of protective language developed for contracts. Reclamation has developed a revised form of water service contract that would be used for all new long-term contracts from the project. All existing contracts entered into since 1995 contain a subarticle that allows for review and modification of the terms and conditions of the contract by Reclamation, at any time, to avoid or minimize impacts to endangered species or other valuable natural resources. New contracts would contain similar language and would require review at least every 5 years, to ensure that continued use of the contracted water would avoid or minimize impacts to species and/or critical habitat that are proposed, listed, or designated under the ESA.

Neither Reclamation nor the USACE monitors the diversion, use, or return flow associated with the water service contracts. The diversion works are privately owned structures maintained and operated by the contractors. Diversion of the water made available under these contracts occurs pursuant to state water rights. Prior to taking water under Reclamation contract, OWRD requires all contractors to obtain a water right permit to divert stored water under their contracts. Monitoring of these diversions falls under the jurisdiction of the local OWRD watermaster.

Table 2-13 Storage Volumes under Existing and Pending Irrigation Contracts (USACE 2007a, Table 3-25).

Reach	Reservoir Providing Water	Number of Contractors	Total Acre-feet Contracted	Total Acres Served
Willamette River				
Downstream of Santiam River	All	53	23,275.32	11,593.40
Santiam River - Long Tom River	All except Santiam	24	12,424.54	8,890.52
Long Tom River - McKenzie	All except Santiam	6	768.75	334.50
McKenzie River - Coast Fork	Fall Creek,	1	9.50	3.80

15 The 205 contracts presently in force cover approximately 3% of the available conservation storage space.

Reach	Reservoir Providing Water	Number of Contractors	Total Acre-feet Contracted	Total Acres Served
Long Tom River	Fern Ridge	63	24,594.275	10,310.20
Middle Fork Willamette River				
Downstream of Fall Creek	Fall Creek,	4	958.73	498.29
Fall Creek - Dexter	Dexter/Lookout	4	94.75	37.90
Fall Creek	Fall Creek	2	12.50	5.00
Coast Fork Willamette River				
Middle Fork - Row River	Dorena, Cottage	10	1,166.05	470.21
Row River - Cottage Grove	Cottage Grove	1	56.387	45.11
Row River	Dorena	1	51.00	20.40
McKenzie River	Blue River, Cougar	38	1,740.165	915.96
Santiam River to Forks	Detroit/Big Cliff,	8	1,835.05	1,882.60
North Santiam River	Detroit/Big Cliff	34	12,269.045	7,071.36
South Santiam River	Green Peter, Foster	18	1,174.61	596.08
TOTALS		**267**	**80,430.672**	**42,675.33**

Reclamation would require new water service contracts to comply with state and Federal fish screening and passage standards, and existing contractors would be notified of their responsibility to comply with these standards. New contracts would include language requiring the contractor to submit written verification that any required fish passage structures are compliant with state and Federal standards, and that the contractor would install, operate, and maintain such structures throughout the contract period.

2.10 FISH HATCHERIES & RELATED PROGRAMS

Congress recognized that the 13 dams and 42 miles of revetments associated with the Willamette Project would adversely impact the fisheries resources of the Willamette River and authorized the construction, operation, and maintenance of hatcheries and related facilities to mitigate for fish losses (HD 544, 75th Congress, 3rd Session, 1938; Public Law 732, 79th Congress, 2nd Session, 1946). The USACE funds ODFW to manage and operate all facilities associated with the Willamette Hatchery Mitigation Program. Hatchery facilities are distributed throughout the Willamette Basin in tributaries with USACE dams that formerly contained large historical populations of spring Chinook salmon and winter steelhead (Figure 2-5). Most of the hatcheries also operate satellite fish collection facilities for broodstock collection and as collection sites for adult fish that are released into areas upstream of USACE dams.

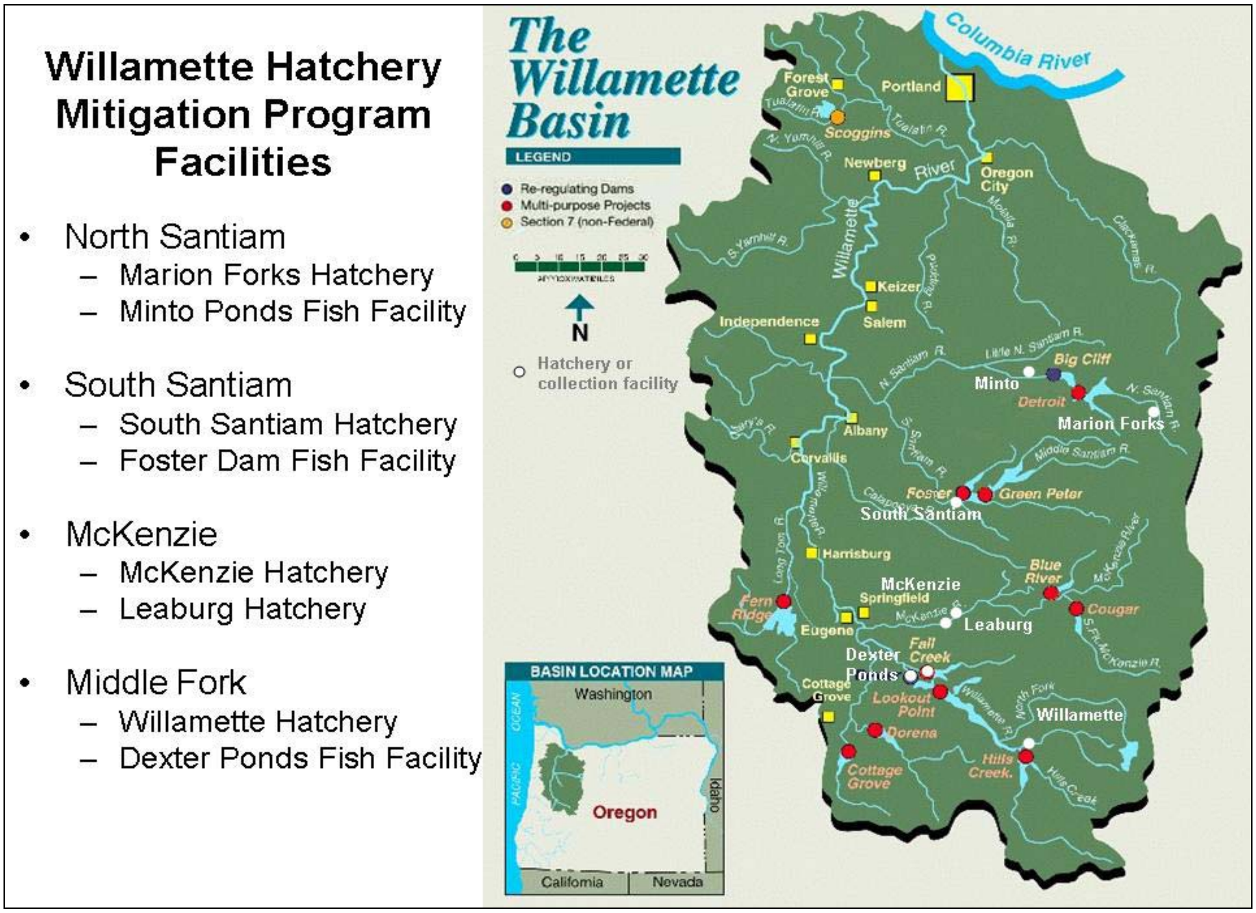

Figure 2-5 Location of USACE-funded Dams, Hatcheries, and Collection Facilities (USACE 2007a).

The State of Oregon contributes additional funds to each hatchery facility based on a percentage described in the 1990 Cooperative Agreement as described in Table 2-14 (below). The percentage of state funds varies with each facility, and the USACE proposes to continue funding each facility according to these percentages until a new agreement is negotiated. The mitigation production requirements for each facility are described in the 1990 Cooperative Agreement and are discussed in more detail in the following sections. Currently, the program funds production of spring Chinook salmon, summer steelhead, and rainbow trout at eight facilities.

Table 2-14 Summary of Cost-sharing Arrangements for USACE-funded Hatcheries and Collection Facilities (USACE 2007a).

Subbasin	Hatchery Program	Hatchery Facility	Operation and Maintenance	Funding percentages**	
				USACE/BPA	ODFW
North Santiam	North Santiam Spring Chinook	Marion Forks Hatchery	ODFW	83.75%	16.25%
		Minto Pond Fish Facility	ODFW		
South Santiam	South Santiam Spring Chinook	South Santiam Hatchery	ODFW	70%	30%

Subbasin	Hatchery Program	Hatchery Facility	Operation and Maintenance	Funding percentages**	
				USACE/BPA	ODFW
	Summer Steelhead	Foster Dam Fish Facility	ODFW/USACE		
McKenzie	McKenzie Spring Chinook	McKenzie Hatchery	ODFW	50%	50%
		Leaburg Dam*	EWEB	0%	0%
Middle Fork Willamette	Middle Fork Willamette Spring Chinook	Willamette Hatchery	ODFW	83.75%	16.25%
		Dexter Pond Collection Facility	ODFW/USACE		
McKenzie	Rainbow Trout	Leaburg Hatchery	ODFW	100%	0%

*Leaburg Dam is owned and operated by the Eugene Water & Electric Board (EWEB). The USACE does not own, fund, or operate Leaburg Dam, but the ladder is used to collect wild hatchery broodstock and to remove hatchery spring Chinook from the wild fish sanctuary upstream of Leaburg Dam.
** Cost sharing is based on the 1990 Cooperative Agreement.

2.10.1 Spring Chinook Reintroduction/Outplant Program

Proposed Action: **The Action Agencies would continue the Spring Chinook Reintroduction/Outplant Program and evaluate the long-term feasibility of establishing viable spring Chinook salmon populations in existing habitat in the North Santiam above Detroit Dam, South Santiam above Foster Dam/Green Peter Dam, South Fork McKenzie above Cougar Dam, and into the Middle Fork Willamette above Lookout Point and Hills Creek Dams.**

For the past 15 years, ODFW has been releasing excess adult hatchery spring Chinook collected at USACE facilities into historic habitat, including areas upstream of USACE dams. Initially, these releases were intended to provide nutrient transfer from the ocean to freshwater and juvenile fish to serve as a prey base for native resident fish (bull trout) and wildlife. While supplementing natural production of spring Chinook was not one of the original goals, field observations indicated that some juvenile fish were being produced upstream of the dams and passing downstream successfully (Taylor 2000; Beidler and Knapp 2005). Thus, ODFW expanded releases, and currently ODFW and the USACE release (outplant) excess hatchery adults (and some wild adults in certain circumstances) above USACE dams in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. Operation of the Reintroduction/Outplant Program has been coordinated by an informal interagency group of biologists from ODFW, NMFS, USFWS, USACE, and U.S. Forest Service. Details of these past releases, including summaries of the limited data regarding juvenile production, are described in Beidler and Knapp (2005).

The outplant/reintroduction component of the Proposed Action is included in the Hatchery Program section because all of the outplanted fish are typically collected during normal broodstock collection at the traps near the base of the dams. The existing hatchery-related facilities are currently used to collect fish for broodstock and outplanting efforts. The following paragraphs summarize the major components of the Spring Chinook Reintroduction/Outplant Program that are part of the revised proposed action in the Supplemental BA (USACE 2007a).

The Action Agencies would carry out and evaluate these activities for 15 years (3 generations) to increase the percentage of natural-origin fish returning to the Willamette Basin. Outplanting protocols would employ techniques and strategies to collect, hold, and release outplants in a manner that increases the likelihood for spawning success and ensures that outplanted fish represent the range of life history characteristics of the natural population (to the extent possible with the current temperature regime). The releases would be conducted in accordance with the Willamette FPMP, described below, which specifies the operating schedule for each fish facility, the number and origin of adult fish released from each fish facility above the dams, and handling, transport, and release protocols for the reintroduced fish. The Willamette FPMP would be updated annually.

2.10.1.1 Willamette FPMP: Fish Disposition & Outplant Protocol Development

Proposed Action: The Action Agencies would prepare the Willamette FPMP, including the "Fish Disposition and Outplant Protocol" sections of each chapter. The FPMP would be completed within 2 months of issuance of the Biological Opinion, and updated annually.

The Fish Disposition and Outplant Protocol section of the Willamette FPMP would serve as an annual reintroduction/outplanting plan that describes the number, timing, origin, and destination of adult spring Chinook to be outplanted upstream of USACE dams and into other accessible habitat. These chapters would also be attached as Section 15 of each HGMP. The Action Agencies and ODFW, through the FPHM Committee, would adjust these protocols annually based on expected run size, recent RM&E results, structural changes at the facilities, run timing/size, and strategies identified in the ESA-recovery planning process or hatchery reform efforts, such as the Columbia River Hatchery Reform Project (NMFS 2006a)

Rationale

To date, there has been no formal fish passage or outplant plan to guide spring Chinook fish passage and reintroduction in the Willamette Basin – these activities have been overseen on an as needed basis by the interagency SCAB Committee and implemented by hatchery and USACE staff. By formally developing and updating these protocols annually, all agencies at all levels (i.e., policymakers to hatchery technicians) would have written explanation of the outplanting and reintroduction program for the coming year, including timing, numbers, and location of fish releases; and the specific protocols for conducting the releases. This would also enable Federal land management agencies (USFS and U.S. Bureau of Land Management [BLM]) to appropriately allocate resources for ESA consultations on their land based on known presence of ESA-listed species released in the vicinity of their land.

2.10.1.2 Current Reintroduction & Outplant Protocol

The following actions describe protocols listed in the May 15, 2006 letter from NMFS to the USACE and ODFW. These protocols were developed and agreed upon by the interagency SCAB Committee, and the USACE has agreed to follow them. The SCAB Committee also developed preliminary guidelines regarding the location and frequency of collect fish for outplanting; and guidance on when and where to release fish at the various release locations to increase the likelihood of spawning success.

Proposed Action: The Action Agencies would ensure that outplanted fish represent the life history characteristics of the natural population (to the extent possible) and promote successful production. Timeline: ongoing/immediate.

The Action Agencies would ensure that all outplanted fish are of a suitable stock for reintroduction efforts (i.e., UWR spring Chinook, see Section 3.4); fish represent the full range of life history characteristics exhibited by the naturally spawning populations; and that the specific fish are selected to improve the likelihood of producing juveniles. The Action Agencies would ensure consideration of age/size distribution, condition, and sex ratio of outplanted fish. The Action Agencies would also consider the use of other life history stages (e.g., juveniles) in reintroduction efforts, if the recommended by the FPHM Committee to increase productivity.

Rationale

A successful reintroduction and supplementation program would depend on the use of fish that represent the range of genetic diversity and life history characteristics of the natural-origin portion of the UWR spring Chinook ESU. The Action Agencies would balance these needs with considerations for ensuring that collection and release timing of outplants are planned to ensure the greatest likelihood of seeding available habitat and improving spawning success.

Proposed Action: The Action Agencies would collect, hold, transport, and release outplanted fish in a manner that increases the likelihood for spawning success. Timeline: ongoing/immediate.

- Until new fish collection facilities are constructed, the Action Agencies (often through ODFW) would operate fish facilities in a manner that minimizes harm and stress to adult spring Chinook by implementing new handling, transport, and release protocols. These protocols would be described in more detail in the Fish Disposition and Outplant Protocol section of the FPMP (and attached as Section 15 of the HGMP). In general, the USACE would implement the following practices to reduce stress on adult Chinook handled at Minto Pond, Foster, Dexter, and Cougar fish facilities, and at other locations where fish may be collected (e.g., McKenzie Hatchery or Leaburg Dam), when appropriate:
- Whenever possible, use MS-222 or Aqui-S/Clove oil as an anesthetic instead of CO_2 (not always possible if fish are released into areas with allowable harvest).
- Transport adults at a loading density of at least 25 gallons/fish (i.e., 50 fish/1,500-gallon tank).
- Treat outplanted fish with erythromycin and oxytetracycline as appropriate.
- Use Nov-Aqua in transport tank to reduce stress during transport.
- Minimize the difference in water temperature between the truck and receiving waters.

Rationale
These activities should reduce stress on adult fish as they are handled, transported, and released. Reducing stress should reduce the susceptibility of outplanted fish to various diseases; ultimately reducing the high rates of pre-spawning mortality that were documented in some years. Reductions in pre-spawning mortality are necessary to ensure successful production upstream of USACE dams or in other historic habitat (e.g., Little North Santiam River).

Proposed Action: The Action Agencies would employ safe release methods for transported fish. Timeline: ongoing/immediate. Modify release sites to comply with these criteria as soon as possible.

Until new release sites are developed, the Action Agencies would increase the likelihood that outplanted fish would survive to spawn by:

- Minimizing the distance between the truck and the receiving waters.
- Avoiding the use of collapsible hoses.
- Releasing fish into low-velocity water with adequate depth and proximity to holding habitat.
- Attempting to avoid releasing fish in close proximity (spatially or temporally) to recreational use.

Rationale
Release locations in the many subbasins were selected opportunistically at locations where managers could get the liberation trucks relatively close to the river. Release sites were not selected based on the suitability of surrounding habitat for providing recovery, holding, and spawning habitat for released adults. Many of the current release sites have relatively poor river access, forcing drivers to release fish using methods that elevate stress or cause direct or delayed injury or mortality. These release practices (e.g., use of collapsible hoses, sliding on tarps, direct release from bridges, etc) have likely contributed to high pre-spawning mortality of outplanted fish. Furthermore, some sites are located at river access points that experience heavy recreational pressure that leads to disturbance, harassment, or poaching of outplanted fish. Implementation of new release protocols should reduce the incidence of stress, injury, and mortality, which would translate to higher spawning success.

Proposed Action: The Action Agencies would work with fishery co-managers and land management agencies to develop suitable release sites for adult spring Chinook above Detroit, Foster, Lookout Point, Hills Creek, and Cougar reservoirs. Work with the FPHM Committee to identify small fixes to current sites in 2008, but ensure that any new facilities are developed based on monitoring efforts associated with the outplant program. When suitable sites are identified, work with land management agencies (e.g., USFS and BLM), or private landowners to develop infrastructure.

The Action Agencies would work with state and Federal co-managers and landowners (through the FPHM Committee) to identify potential new release sites for spring Chinook salmon upstream of several reservoirs. The USACE would provide information on the quality and quantity of holding and spawning habitat in the vicinity of potential sites using the database developed in the habitat assessment completed[16] by R2 Resource Consultants. The FPHM Committee would select sites based on proximity to suitable holding and spawning habitat and the ability to develop suitable infrastructure necessary to safely release UWR spring Chinook (and potentially UWR winter steelhead) into quality habitat as part of the spring Chinook reintroduction program.

Rationale

Poor release conditions likely increase the incidence of pre-spawning mortality in adult releases. New release sites must be developed to allow safe transfer of fish from the truck, adequate recovery in pools without recreational pressure or poaching, and reasonable proximity to quality holding and spawning habitat. Improving release conditions should reduce stress and associated pre-spawning mortality.

2.10.1.3 Outplanting Research, Monitoring, & Evaluation

Proposed Action: The Action Agencies would develop and carry out a thorough RM&E program to monitor the progress of the reintroduction/outplant program.

During the 15 year evaluation period, the RM&E program would be used to determine if adult fish (or other life stages) can be safely collected, sorted, transported, and released into the upstream habitat; habitat upstream of the dam is capable of supporting the holding, spawning, and (to the extent necessary) rearing life stages of spring Chinook; the reservoir environment is capable of sustaining juveniles (in terms of productivity and predation) or if juveniles can safely bypass the reservoir environment; juvenile survival through the dam is sufficient to provide a benefit to the population; and habitat conditions downstream of the dams support juvenile rearing/outmigration, and adult upstream migration. The data collected would result in recommendations on: (1) locations where it is feasible to re-establish self sustaining populations (short term and long term); (2) potential population size for each subbasin; (3) operational methods for higher juvenile and adult survival; (4) infrastructure needs (i.e., structural modifications) to ensure long term viability of populations; and (5) genetic considerations for broodstock in each subbasin. This program must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and following the principles and strategic questions developed by the committee.

[16] As of 1/15/2009 this report was still being compiled, but is expected to be completed by the time the Biological Opinion is issued.

2.10.2 North Santiam Spring Chinook Hatchery Program

Proposed Action: **The Action Agencies would continue funding 83.75% of the O&M costs of Marion Forks Hatchery, the primary rearing facility for the North Santiam spring Chinook program, and the Minto Pond facility, the broodstock collection and juvenile acclimation facility. In accordance with the 1990 Cooperative Agreement, the annual funding level would be based on what is required to rear no more than 84,000 pounds of juvenile spring Chinook and steelhead, which is the USACE mitigation responsibility for lost salmon and steelhead spawning and rearing habitat on the North Santiam River upstream of Detroit and Big Cliff Dams.**

Currently, the North Santiam spring Chinook program releases about 61,000 pounds of spring Chinook smolts annually. The goals of the North Santiam spring Chinook program are to:

- Mitigate the loss of spring Chinook catch in sport and commercial fisheries caused by construction and operation of Big Cliff and Detroit Dams.
- Provide adequate fish to the hatchery to maintain the broodstock to perpetuate program goals as outlined in the ODFW *Santiam River Subbasin Fish Management Plan* (OAR 635-500-1666).
- Maintain a suitable conservation broodstock for ongoing and future population recovery efforts throughout the subbasin, including reintroduction efforts above the Big Cliff/Detroit dam and reservoir complex.

Because of the conservation role of this hatchery program, the USACE proposes to operate the North Santiam spring Chinook program as an integrated hatchery program with conservation-oriented genetic protocol. The operation of the program is described in detail in the North Santiam spring Chinook HGMP (ODFW 2008a; USACE 2007a).

2.10.2.1 Minto Pond Fish Facility

Proposed Action: **The Action Agencies would operate and rebuild the Minto Pond Fish Facility. The conceptual timeline for reconstruction of Minto Pond is described in Section 2.12, Structural Modifications.**

The USACE owns the Minto Pond facility on the North Santiam River (Figure 2-6 below) and the 21.32 acres surrounding it. This facility is used to collect adults for the North Santiam spring Chinook program. The facility was designed as an adult salmon collection facility and was not designed to accommodate live sorting of adult fish. This facility also handles adult winter and summer steelhead, which are returned to the river to spawn naturally, recycled downstream to increase harvest opportunities, or given to local food banks. Migrating adults are blocked by the barrier dam and guided to the fish ladder entrance. Attraction water is provided from an intake and 36-inch in diameter pipe located upstream of the barrier dam. The trap consists of a short fish ladder, pre-sort holding pool, a fish lock and brail, an anesthetic tank, and a sorting table. Sorted fish are routed via PVC tubes to various locations, including a concrete post-sort holding pond that measures 164-feet long by 32-feet wide, and is 6-feet deep. The holding pond was constructed in 1975, but was recently divided into four alleyways with vertical aluminum poles. The roof of the sorting and spawning facility has been retrofitted to facilitate transfer of fish from the anesthetic tank to the rooftop where they are loaded via a tube onto a truck for transportation.

Figure 2-6 Minto Pond Fish Facility, North Santiam River near Niagara, Oregon.

The Action Agencies would build a new fish collection facility at Minto Pond, if funding is available, that complies with NMFS criteria for upstream passage/collection facilities. The facility would provide adequate attraction of fish into the trap, automated sorting (when possible), and water-to-water transfer of fish into transport trucks. The facility would also serve as an effective juvenile acclimation facility that allows for volitional release. In the Supplemental BA (USACE 2007a), the Action Agencies indicate that preliminary design work has been included in the USACE's fiscal year 2008 budget, but there is not a certain date proposed for construction and initial operation of the proposed facility.

In the short term, the USACE proposes to continue operating Minto Pond in its current condition (with minor safety upgrades) while it completes designs for a new facility.

2.10.2.2 Marion Forks Hatchery

Proposed Action: The Action Agencies would operate and maintain the Marion Forks Fish Hatchery. Timeframe: Immediate/ongoing.

Marion Forks Hatchery is located on 15 acres owned by the USFS, Willamette National Forest (Figure 2-7 below). A 1949 Memorandum of Understanding between the USACE and the USFS granted the USACE use of the 40-acre parcel associated with Marion Forks Hatchery. All structures associated with Marion Forks are the property of the USACE.

Figure 2-7 Marion Forks Fish Hatchery, Detroit Ranger District, Willamette National Forest.

Marion Forks Hatchery has 34 stacks of heath stack vertical incubators. Because of the hatchery's cold water supply, it is equipped with a water heating system that enables the operators to increase growth rates in attempts to meet target sizes. Marion Forks Hatchery is equipped with 12 Canadian-style troughs and 48 circular ponds. There are no spawning facilities at Marion Forks; all spawning occurs at Minto Pond. The ODFW also raises Clackamas (011 stock) and Sandy (019 stock) spring Chinook; South Santiam River (024 stock) summer steelhead; and rainbow trout at Marion Forks, but the majority of the production is North Santiam (021 stock) spring Chinook.

The Action Agencies propose to continue funding 83.75% of the operation and maintenance of Marion Forks Fish Hatchery as the primary hatchery facility used to meet the North Santiam spring Chinook mitigation requirements.

2.10.2.3 Actions for both Minto Pond & Marion Forks Hatchery

Proposed Action: The Action Agencies would resolve hatchery infrastructure maintenance needs and develop a long-term Hatchery Maintenance Plan. Timeframe: safety upgrades immediate/ongoing; complete Hatchery Maintenance Plan in September 2007; carry out maintenance according to schedule in the plan.

The USACE and ODFW are developing a prioritized list and database of maintenance needs at each hatchery facility, including Marion Forks Hatchery and the Minto Pond Fish Facility. The Action Agencies and ODFW would use this list to develop a Hatchery Maintenance Plan that identifies long-term maintenance needs for each facility. The Action Agencies and ODFW would develop a strategy to address these needs through annual budget requests or other processes. The Action Agencies and ODFW would continue to implement actions identified in the Minto Pond safety inspection report.

2.10.2.4 Broodstock

Proposed Action: The Action Agencies would continue use of the North Santiam (stock 021) spring Chinook. Timeframe: ongoing/immediate.

Broodstock for the North Santiam spring Chinook (stock 021) were derived from the local wild population. Because the North Santiam spring Chinook Program is both a mitigation and conservation hatchery program, this is the most suitable stock to propagate.

Proposed Action: The Action Agencies would continue collecting all North Santiam spring Chinook broodstock at Minto Pond. Timeframe: ongoing/immediate.

All broodstock for the North Santiam spring Chinook program are collected at the Minto Pond Fish Facility located about 3 miles downstream of Big Cliff Dam. A 12-foot high barrier weir at the Minto Pond facility spans the North Santiam River and serves as a barrier to upstream-migrating fish, directing them into the trap. Any changes in broodstock collection location, including collection at Upper or Lower Bennett Dam (owned by the Santiam Water Control District and the City of Salem), would be discussed in the FPHM Committee.

Proposed Action: The Action Agencies would continue to collect broodstock throughout the run to ensure the hatchery population is similar to the naturally spawning population.

The Minto Pond Fish Facility is usually opened in March to collect and pass UWR winter steelhead. Adult spring Chinook are collected at the trap between mid-May and October. However, due to cold temperature releases from Detroit and Big Cliff Dams, spring Chinook typically do not arrive at Minto Pond until mid-July, with the majority arriving in August. The Action Agencies propose to continue the current practice of allowing Chinook salmon broodstock to hold in the river below Minto and be collected between August and October. If water temperature control is installed at Detroit Dam (see Section 2.12 [structural actions]), then the Action Agencies and ODFW, through the FPHM committee, would revisit this practice, as fish would likely return to the facility earlier. Likewise, reconstruction of the Minto Pond Fish Facility may warrant or enable modifications to the broodstock collection protocol to ensure that the broodstock represents the entire range of run timing. If RM&E indicates differences in run timing of hatchery and wild fish is substantially different, then modifications to the broodstock collection protocol should be made. Potential modifications include collection of early-run fish from Upper Bennett Dam. Any changes in broodstock collection timing, including collection at Upper or Lower Bennett Dam, would be discussed in the FPHM Committee.

Proposed Action: The Action Agencies would incorporate an appropriate percentage of natural-origin fish incorporated into the broodstock to ensure the hatchery population is similar to the naturally spawning population. Timeframe: ongoing/immediate.

The Action Agencies and ODFW would increase the percentage of natural origin fish into the North Santiam spring Chinook broodstock in order to achieve the management goal of operating the program as an integrated program with a conservation-oriented genetic protocol. The percentage of non-adipose, fin-slipped fish incorporated into the brood would follow the guidance in Table 2-15 (below). The Action Agencies would modify these guidelines based on recommendations from the Hatchery Scientific Review Group (HSRG) and/or the FPHM Committee.

Table 2-15 Proposed Broodstock Collection Guidelines for the North Santiam Spring Chinook Hatchery Program.

North Santiam Spring Chinook	Hatchery Broodstock			Reintroduction Above Detroit Reservoir Proportion of Wild and Hatchery Fish	
Returns of Chinook to North Santiam (hatchery and wild) as indexed by Bennett Dam counts	Maximum percent wild fish in hatchery broodstock (600 fish goal)	Corresponding maximum number wild fish in broodstock	Maximum percent of wild pop. taken for brood	Wild fish	Hatchery fish
<3,000 (low run)	30	180	50	ensure wild fish incorporated into broodstock	As needed to have minimum spawning escapement of at least 500 fish
3,000-7,000 (medium run)	40	240	30	none at this time	
>7,000 (high run)	50	300	20	none at this time	

2.10.2.5 Adult Transport, Holding, & Prophylactic Treatment

Proposed Action: The Action Agencies would continue to spawn North Santiam spring Chinook on-site at the Minto Pond Fish Facility. Timeframe: immediate/ongoing.

Spawning/mating occurs on-site at the Minto Pond Fish Facility; no transport of broodstock is necessary. With the current temperature regime, most broodstock are held in the river below Minto Dam and are retained in the holding ponds at Minto Pond beginning with collections in mid-July. The Action Agencies do not propose any changes to the holding protocol for broodstock. In 2006, ODFW experimented with holding early-arriving adults at Minto Pond between July and September, and these adults experienced relatively low pre-spawning mortality. The Action Agencies support continued evaluations of the holding potential of early-arriving brood, if possible, given the current water temperature regime (or of brood collected at Bennett Dam).

2.10.2.6 Mating

Proposed Action: The Action Agencies would continue to use random spawning protocol with a 1:1 male-to-female ratio. Timeframe: immediate/ongoing.

The Action Agencies do not propose any changes to the spawning protocol, unless results of RM&E indicate that spawning is not truly random with respect to run representation, age, and size of broodstock.

Fish are selected and paired at random in order to minimize selective pressures from hatchery practices. The typical sex ratio of returning adults is almost 2:1 male to female, but the typical spawning sex ratio for this program is a 1:1 male-to-female. Jacks are used in approximately the same proportion as they occur in the return. Males are not reused. Collection of 300 males and 300 females allows for an annual egg take of around 1.1 to 1.3 million eggs. If the hatchery reduces the number of eggs retained, a representative sample of each male/female cross is culled. Exceptions may occur if there is a high degree of disease or epidemics associated with certain parents; if this occurs, offspring of diseased parents may be culled, in order to maximize long-term survival of the brood.

2.10.2.7 Incubation & Rearing

Proposed Action: The Action Agencies would continue to incubate and rear all North Santiam spring Chinook at Marion Forks Hatchery. Timeframe: immediate/ongoing.

The Action Agencies do not propose any changes to the incubation and rearing protocol, with the exception of changes necessary to accommodate experimental changes in release size or timing.

Eggs are transferred immediately to Marion Forks Hatchery for incubation and rearing. All North Santiam spring Chinook are reared at Marion Forks Hatchery. Egg take typically ranges from 900,000 eggs to 1.5 million eggs, which allows surplus for bacterial kidney disease (BKD) culling. Fish are ponded at between 1650-1850 temperature units (TUs), which usually occurs between mid-February and mid-March. Egg to fry survival averages around 83%; fry to smolt survival averages around 95%, and overall egg to smolt survival is around 85%. Due to cold water temperatures, fish raised at Marion Forks Hatchery grow relatively slowly. Details regarding incubation, rearing, and growth rates are described in Chapter 9 of the HGMP (ODFW 2008a).

2.10.2.8 Marking

Proposed Action: The Action Agencies would continue to adipose fin-clip and otolith mark all North Santiam spring Chinook at Marion Forks Hatchery. Timeframe: immediate/ongoing.

The Action Agencies propose to continue the current practice of adipose fin-clipping and otolith marking all North Santiam spring Chinook.

Proposed Action: The Action Agencies would insert coded wire tags (CWTs) into all juvenile hatchery fish in addition to current practice of adipose fin-clipping and otolith marking. Timeframe: purchase CWTs for all fish in experimental releases in FY 2008. Include purchase of CWTs for all North Santiam releases in FY 2009 budget request and out years.

In addition to the current practice of adipose fin-clipping and otolith marking all hatchery releases, the Action Agencies propose to insert CWTs into all hatchery releases. Tag codes should be assigned according to releases in order to evaluate alternative release strategies.

2.10.2.9 Acclimation & Release

Proposed Action: The Action Agencies would continue acclimating and releasing the majority of North Santiam Spring Chinook at Minto Pond Facility. Timeframe: immediate/ongoing.

The Action Agencies propose to continue acclimating and releasing the majority of smolts at Minto Pond and allowing for volitional release. The Action Agencies would provide flows that allow acclimation and volitional release whenever possible until a new facility is built that functions throughout a wider range of river levels. In previous years, some North Santiam spring Chinook have been directly released into the North Santiam River. However, in recent years, all North Santiam spring Chinook releases have been acclimated at Minto Pond. Typical acclimation (when releases from Big Cliff Dam permit) lasts at least 3-4 weeks depending on the physiological readiness of the fish. The fish are held in the pond for 3-4 weeks and then the screens are pulled to allow the fish to emigrate when they are ready, which may take up to 2 weeks. High spring flows can sometimes render the pond unusable for acclimation because flow-through is reduced.

Proposed Action: The Action Agencies would experimentally release a portion of hatchery juveniles at a size and time more similar to natural-origin fish. Timeframe: the FPHM Committee would develop the scope and details of the experimental release within 1 year of issuance of the biological opinion, targeting release in 2009. The FPHM Committee would also develop a suitable evaluation to accompany the release (e.g., PIT tag), which may be combined with objectives of other studies.

The Action Agencies, through ODFW, would shift production to release a group of juveniles at a size and time that more closely approximates the life history pattern of natural-origin juveniles. The Action Agencies propose an experimental release of 200,000 subyearlings as described in Table 2-16, but would thoroughly discuss the details of this release with the FPHM Committee. The Action Agencies propose to initiate the experimental release in the North Santiam Basin due to the relatively low risk to natural production and the ability of Marion Forks Hatchery to produce fish of a smaller size. However, the Action Agencies seek input from FPHM on the most appropriate subbasin for the release, and also seek review of the potential action by the HSRG/CRHRP. The Action Agencies would finalize details of the release with the FPHM committee, develop a monitoring and evaluation process, and determine if the releases are worth implementing on a larger scale in other basins.

Table 2-16 Proposed Release Schedule for North Santiam Spring Chinook.*

Life Stage	Release Location	Release Date	Mean Size at Release (fish per lb)	Number of Fish Released	Total Pounds Released
Eyed Eggs				0	0
Unfed Fry				0	0
Fry	Big Lake			1,500	15
Fingerling	Detroit Reservoir	June	200	100,000	500
Subyearling**		March	20	200,000**	10,000
Yearling (age-1 smolts)	North Santiam River (at Minto)	March	11	500,000***	45,455
TOTALS				701,500	55,955

* New releases are highlighted in green; changes in historical releases are in yellow. Proposal to be finalized by the FPMP Committee within one year post-issuance, targeting an initial experimental release in 2009.
** Subyearling release would be implemented experimentally in 2009.
*** 667,000 smolts were released annually until and including 2007. 500,000 smolts represent a target smolt release in years after 2007 when the subyearling release is implemented.

2.10.2.10 Spring Chinook Reintroduction/Hatchery Outplant Program & Disposition of Fish Arriving at Minto Pond

Several species of fish arrive at the Minto Pond Facility throughout the year, including spring Chinook, winter steelhead, and non-native hatchery summer steelhead. In addition to collection for broodstock needs, fish are transported to various locations based on management priorities (Table 2-17 below). Priorities for disposition of excess broodstock and non-hatchery species arriving at the Foster Trap are determined by balancing goals for natural production, the Spring Chinook Reintroduction/ Outplant Program, hatchery management, and harvest opportunities; while ensuring that tribal obligations are satisfied. The Action Agencies and ODFW balance these goals with the physical limitations of the existing facility and the associated demands on hatchery personnel. In recent years, the majority of excess spring Chinook broodstock have been collected and transported to unseeded, historic habitat in efforts to reestablish natural production of spring Chinook (see Spring Chinook Reintroduction/Outplant Program in Section 2.10.2). In the North Santiam Basin, adult spring Chinook have been released at three locations along the North Santiam upstream of Detroit Reservoir and at Cleator Bend on the Breitenbush River. Unmarked spring Chinook have been released into the Little North Santiam River (a tributary located downstream of Big Cliff Dam). Fish are also passed over the barrier dam at Minto and into the 4 miles of habitat between Minto and Big Cliff Dam. A summary of these releases is found in Beidler and Knapp (2005).

Table 2-17 Management Goals for Fish Collected at Minto Pond.

Species	Destination	Target Number of Adult Fish		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	420	180	30*
	North Santiam above Minto Pond	As needed to meet unclipped goal, after broodstock target met	500	
	North Santiam above Detroit Dam	2000* (1,200 in short-term)	None at this time given downstream survival uncertainty; Long-term goal is to use wild fish.	
	Breitenbush above Detroit Dam	1000* (600 in short-term)	None at this time given downstream survival uncertainty; Long-term goal is to use wild fish.	
	Little North Santiam at The Narrows	0	400	
Winter steelhead	North Santiam above Minto	0	All	
	Remove from system	All	0	
Summer steelhead	Recycling below Minto	Any excess to brood	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

* Sliding scale based on run size.
** These targets are for actual spawners. May need to adjust for prespawning mortality.

Detailed protocols for disposition of excess hatchery broodstock, wild fish, and other species collected at Minto Pond would be contained in the "Fish Disposition and Outplant Protocols" section of the Willamette FPMP. The FPMP would contain detailed, on-the-ground disposition protocols for all species of fish (clipped/unclipped) arriving at Minto Pond including excess adult hatchery fish. Organized by date, it would specify priorities for disposition of wild/unclipped fish; and establish numerical goals (and perhaps minimum number of females) for release at each release site. These numerical goals would updated annually by the FPHM Committee.

2.10.2.11 Research, Monitoring & Evaluation Needs for the North Santiam Spring Chinook Salmon Hatchery Program

The following RM&E questions are specific to the North Santiam Basin and the spring Chinook program. Any RM&E recommendations must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

1. Investigate options for increasing North Santiam spring Chinook.

2. Reduction of hatchery fish spawning in the wild.
3. Testing assumptions about fish mixing the river below fish traps.
4. Experimental release of smaller spring smolts or fall?
5. Potential to collect early-run fish at Bennett dams and hold at Minto Pond to ensure incorporation of early run fish into the broodstock.
6. Potential to collect early-run fish at Minto for potential passage upstream of Detroit.
7. Investigate improvements to fin-clipping - try using automated trailer?

2.10.3 South Santiam Spring Chinook Hatchery Program

Proposed Action: The Action Agencies would continue funding 70% of the operations and maintenance costs of South Santiam Hatchery, the primary rearing facility for the South Santiam Spring Chinook Program; and the Foster Fish Facility, the broodstock collection facility. In accordance with the 1990 Cooperative Agreement, the annual funding level would be based on what is required to rear no more than 71,000 pounds of juvenile spring Chinook and steelhead, which is necessary to mitigate for the 1400 spring Chinook adults that historically spawned annually in the areas upstream of Foster Dam, and the areas inundated by and between Foster and Green Peter Dams.

Currently, the South Santiam Spring Chinook Program releases about 87,833 pounds of spring Chinook smolts annually. The goals of the South Santiam spring Chinook program are to:

- Mitigate the loss of spring Chinook catch in sport and commercial fisheries caused by construction and operation of Foster Dam.
- Provide adequate fish to the hatchery to maintain the broodstock to perpetuate program goals as outlined in the ODFW *Santiam River Subbasin Fish Management Plan* (OAR 635-500-1666).
- Maintain a suitable conservation broodstock for ongoing and future population recovery efforts throughout the subbasin, including reintroduction efforts above the Foster/Green Peter dam and reservoir complex.

Because of the conservation role of this hatchery program, the USACE proposes to operate the South Santiam spring Chinook program as an integrated hatchery program with conservation-oriented genetic protocol. The operation of the program is described in detail in the South Santiam spring Chinook HGMP (ODFW 2008b).

2.10.3.1 Foster Fish Facility

Proposed Action: The Action Agencies would operate and modify the Foster Fish Facility. Timeframe: operation of the current facility is ongoing/immediate. The timeline for constructing significant modifications to the Foster Fish Facility is not identified, but additional information is provided in Section 2.12.

Figure 2-8 Foster Fish Facility. Fish ladder leading to the trap-and-fish elevator.

The USACE owns the Foster Fish Facility, located on the south side of Foster Dam near river mile (RM) 37 on the South Santiam River (Figure 2-8 below), as well as many acres surrounding it. This facility is used to collect adults for the South Santiam Spring Chinook Program. It was designed as an adult salmon collection facility and was not designed to accommodate live sorting of adult fish. This facility also handles adult winter and summer steelhead, which are returned to the river to spawn naturally, passed over Foster Dam (winter steelhead only), recycled downstream to increase harvest opportunities, or given to local food banks. A fish ladder provides access to the approximately 12-foot by 40-foot trap which has a mechanical sweep to crowd fish into an anesthetic tank. From the anesthetic tank (CO_2 is used), fish are manually placed into a mechanical loading bell or slid down 10-inch plastic pipes for placement into the transport trucks. A grate can be lowered to close the ladder to fish passage and is used to control the numbers of adults migrating into the trap during peak run times. Overloading of the trap is possible without this device. Broodstock are transported approximately 10 minutes to the adult holding pond at South Santiam Hatchery; other fish are transported to release sites upstream or downstream of Foster Dam.

Adults holding in the existing trap at the facility

The Action Agencies would significantly modify the fish collection facility at Foster Dam, if funding is available, to comply with NMFS criteria for upstream passage/collection facilities. The facility would provide adequate attraction of fish into the trap, automated sorting (when possible), and water-to-water transfer of fish into transport trucks. The preliminary design also included construction of natural holding pools on the south bank of the river adjacent to the trap, which would replace or augment the holding ponds currently used at South

Santiam Hatchery. In the short term, the USACE proposes to continue operating the Foster Fish Facility in its current condition (with minor upgrades) while it completes designs and prioritizes funding for the modifications.

2.10.3.2 South Santiam Hatchery

Proposed Action: The Action Agencies would operate and maintain the South Santiam Fish Hatchery. Timeframe: immediate/ongoing.

South Santiam Hatchery is located about 2 miles east of Sweet Home, Oregon at the base of Foster Dam on 12.6 acres along the north shore of the South Santiam River at RM 37 (Figure 2-9 below). The hatchery consists of a dividable adult holding pond, a small incubation room, and ten Burrows raceways equipped with 24-inch in diameter pipes to allow for juvenile release. The facility was recently retrofitted with a mechanism to transport broodstock from the adult holding pond to a level area for spawning. The primary hatchery water supply is from Foster Reservoir and the secondary water supply is from a well (primarily used for summer steelhead egg incubation from December through April). Due to high turbidity in Foster Reservoir, incubation past the eyed egg stage is completed at other hatchery facilities, primarily Willamette Hatchery. The South Santiam Hatchery is used primarily for holding, spawning, rearing, and acclimation of the USACE-funded South Santiam Spring Chinook (stock 024) and South Santiam Summer steelhead (stock 024) programs. The facility is also used for rearing Cape Cod rainbow trout (stock 072).

Figure 2-9 Foster Dam and South Santiam Hatchery near Sweet Home, Oregon.

The Action Agencies propose to continue funding 70% of the operation and maintenance of South Santiam Fish Hatchery as the primary hatchery facility used to meet its South Santiam spring Chinook mitigation requirements. Due to water quality issues, South Santiam spring Chinook are moved to Willamette Hatchery (or other facilities) for a portion of their life cycle. The Action Agencies propose to continue late rearing and incubation of South Santiam spring Chinook at South Santiam Hatchery.

2.10.3.3 Broodstock

Proposed Action: The Action Agencies would continue use of South Santiam (stock 024) spring Chinook. Timeframe: immediate/ongoing.

The Action Agencies propose to continue using South Santiam spring Chinook (stock 024) to meet its mitigation responsibilities.

Proposed Action: The Action Agencies would continue collecting all South Santiam spring Chinook broodstock at Foster Fish Facility. Timeframe: immediate/ongoing.

All broodstock for the South Santiam spring Chinook program are collected at the Foster Fish Facility located at Foster Dam (RM 37). Fish are attracted into the fish trap by a fish ladder with an entrance near the powerhouse on the south side of Foster Dam. Any changes in broodstock collection location, including collection at Lebanon Dam, would be discussed in the FPHM Committee.

Proposed Action: The Action Agencies would collect broodstock throughout the run to ensure the hatchery population is similar to the naturally spawning population, including between July 15 and August 15 when the trap has been shut down. Timeframe: immediate/ongoing.

The Foster Fish Facility is usually operated year-round (but checked less frequently) to collect summer steelhead and ESA-listed UWR winter steelhead. Adult spring Chinook are collected at the trap between mid-May and October, with the exception of an annual shut-down period between July 15 and August 15. The trap is checked approximately 3 times per week. Brood are collected throughout the run until September and held in the holding pond at South Santiam Hatchery until spawning in September or October. Broodstock are marked with a color-coded Floy® tag according to arrival date.

The Action Agencies propose to continue the current practice of collecting broodstock throughout the run between mid-May and October. However, the Action Agencies propose to also collect broodstock (and pass spring Chinook over Foster Dam) between July 15 and August 15, when the trap has typically been shut down. This would ensure collection of brood throughout the entire run, and also ensure prompt passage of unmarked spring Chinook over Foster Dam. Reconstruction of the Foster Fish Facility may warrant or enable modifications to the broodstock collection protocol to ensure that the broodstock represents the entire range of run timing. If RM&E indicates that run timing of hatchery origin and natural origin fish is substantially different, then modifications to the broodstock collection protocol should be made. Any changes in broodstock collection timing, including collection at Lebanon Dam, would be discussed in the FPHM Committee.

Proposed Action: The Action Agencies would incorporate an appropriate percentage of natural origin fish incorporated into the broodstock to ensure the hatchery population is similar to the naturally spawning population.

The Action Agencies and ODFW would increase the percentage of natural origin fish into the South Santiam spring Chinook broodstock in order to achieve the management goal of operating the program as an integrated program with a conservation-oriented genetic protocol. The percentage of non-adipose, fin-clipped fish incorporated into the brood would follow the guidance in Table 2-18 below. The Action Agencies would modify these guidelines based on recommendations from the HSRG and/or the FPHM Committee.

Table 2-18 Proposed Broodstock Collection Guidelines for the South Santiam Spring Chinook Hatchery Program.

South Santiam Spring Chinook	Hatchery Broodstock			Above Foster Dam Proportion of Wild & Hatchery Fish	
Returns of Chinook to South Santiam (hatchery & wild) as indexed by May 31 Willamette Falls Counts	**Maximum percent wild fish in hatchery broodstock (900 fish goal)**	**Corresponding maximum number of wild fish in broodstock**	**Maximum percent of wild population taken for brood**	**Wild fish**	**Hatchery fish**
<30,000 (low run)	30	300	50	Ensure wild fish incorporated into broodstock	As needed to have minimum spawning escapement of at least 500 fish
3,000-50,000 (medium run)	30	300	30	Outplant above and below Foster*	
>50,000 (high run)	30	300	20		

* All of the wild fish collected at Foster after broodstock needs are fulfilled.

2.10.3.4 Adult Transport, Holding, & Prophylactic Treatment

Proposed Action: The Action Agencies would continue to hold South Santiam spring Chinook at South Santiam Hatchery; replace with new holding facility adjacent to the Foster Fish Facility. Timeframe: Immediate/ongoing.

Fish have been anesthetized with CO_2 at the Foster Fish Facility; other approved anesthetics cannot be used due to recycling of summer steelhead and hatchery spring Chinook in the fishery below Foster Dam. From the anesthetic tank, fish are manually placed into a mechanical loading bell or slid down 10-inch plastic pipes for placement into the transport trucks and transported approximately 10 minutes to the adult holding pond at South Santiam Hatchery.

An oval concrete broodstock holding pond measuring 148-feet by 47-feet (199,000-gallon capacity) is used for all spring Chinook adult holding. Approximately 1,400 adult spring Chinook are held along with 1,300 adult summer steelhead in this pond. A center divider allows the separation of species and a cross divider allows a separation of male and female Chinook. Approximately 5,000 gallons per minute (gpm) flow through this pond during heavy loading.

Adults held for broodstock are inoculated with erythromycin and oxytetracyclene twice - first at collection and again approximately one month prior to spawning. Bacterial kidney disease and furunculosis are the diseases of concern. Flow-through treatments of formalin (prior to 2000) or hydrogen peroxide (since 2001) occur in the adult holding pond for 1 to 2 hours, 3 days per week, throughout the holding period. Spring Chinook and summer steelhead are often held together in the same holding pool.
The Action Agencies do not propose any changes to the holding protocol for broodstock unless minor improvement can be made to the existing holding pond. The Action Agencies propose modifying the Foster Fish Facility to include construction of new broodstock holding pond on the south bank of the river that simulates a natural holding environment (sinuous banks,

overhangs, and deeper water), as described in Section 6.5.8 of the South Willamette Fish Facilities Improvements Report (McMillen Engineering 2005).

2.10.3.5 Mating

Proposed Action: The Action Agencies would continue to use random spawning protocol with a 1:1 male-to-female ratio. Timeframe: immediate/ongoing.

The Action Agencies do not propose any changes to the spawning protocol, unless results of RM&E indicate that spawning is not truly random with respect to run representation, age, and size of broodstock.

2.10.3.6 Incubation & Rearing

Proposed Action: The Action Agencies would continue to incubate and rear all South Santiam spring Chinook at South Santiam Hatchery, with temporary rearing (eyed egg to fry) at Willamette Hatchery. Investigate options to allow complete rearing at South Santiam Hatchery. Timeframe: immediate/ongoing.

The Action Agencies do not propose any immediate changes to the incubation and rearing protocol.

Egg collection typically ranges from 2.1 to 2.3 million, which has allowed a surplus for BKD culling. No ponding occurs at South Santiam Hatchery. All eggs are transferred to Willamette Hatchery at the eyed stage, because the primary water source from Foster Reservoir can be turbid in the winter months. Fry are transferred back to South Santiam beginning in March. Although fingerling to smolt survival has been above 90%, it has declined in recent years. Details regarding incubation, rearing, and growth rates are described in Chapter 9 of the HGMP (ODFW 2008b).

2.10.3.7 Marking

Proposed Action: The Action Agencies would continue to adipose fin-clip and otolith mark all South Santiam spring Chinook at South Santiam Hatchery. Timeframe: immediate/ongoing.

The Action Agencies propose to continue the current practice of adipose fin-clipping and otolith marking all hatchery spring Chinook.

Proposed Action: The Action Agencies would insert coded wire tags into all juvenile hatchery fish in addition to current practice of adipose fin-clipping and otolith marking. Timeframe: Include purchase of CWTs for all South Santiam releases in FY 2009 budget request and out years.

In addition to the current practice of adipose fin-clipping and otolith marking all hatchery releases, the Action Agencies propose to insert CWTs into all hatchery releases. Tag codes should be assigned according to releases in order to evaluate alternative release strategies.

2.10.3.8 Acclimation & Release

Proposed Action: The Action Agencies would continue acclimating and releasing the majority of South Santiam spring Chinook at Foster Fish Facility; investigate options for acclimating all smolts on-site and allowing for direct release. Timeframe: immediate/ongoing.

The Action Agencies propose to continue acclimating and releasing as many smolts as possible at the Foster Fish Facility. The Action Agencies also propose to investigate operations or structural modifications that would enable acclimation and volitional release of all South Santiam releases (Table 2-19 below). The Action Agencies recommend continuing the fingerling release into Quartzville Creek, pending annual recommendation and coordination with the FPHM committee (including the USFS and BLM).

The majority of South Santiam spring Chinook releases have been into the South Santiam. In previous years, some South Santiam spring Chinook have been directly released into Thomas and Crabtree creeks in the South Santiam subbasin. Some South Santiam spring Chinook are also released into the Molalla River. The majority of South Santiam spring Chinook releases are acclimated and released at South Santiam Fish Hatchery. Prior to 2002, two groups (421,000 smolts total) were transferred from Willamette Hatchery in February and March and acclimated at South Santiam Hatchery for 1 month, before being released into the South Santiam River. Currently 153,000 are transferred from Willamette Hatchery in late February for a 3-week acclimation in the adult holding pond, and then released into the South Santiam via a 24-inch in diameter pipe. The remaining 268,000 are now trucked from Willamette Hatchery and direct released into the South Santiam. A small portion of production is released into Quartzville Creek upstream of Green Peter Reservoir and 20,000 eggs are given to the STEP program for release within the Santiam subbasin.

Table 2-19 Proposed Release Schedule for South Santiam Spring Chinook.

Life Stage	Release Location	Release Date	Number Released	Mean Size at Release	Total Pounds Released
Unfed Fry	Santiam Basin Release (STEP)	May	20,000		
Fingerling	Quartzville Creek	June	100,000	100	1000
1+ Yearling	South Santiam River	February/March	721,000	8.5	84,800
Yearling	South Santiam River	November	300,000	8.1	37,000
1+ Yearling	Molalla River	March	67,000	9.5	7,050
Yearling	Molalla River	November	33,000	8.3	3,975

2.10.3.9 Spring Chinook Reintroduction/Outplant Program & Disposition of Fish Arriving at Foster Fish Facility

Several species of fish arrive at the Foster Fish Facility throughout the year, including spring Chinook, winter steelhead, and non-native hatchery summer steelhead. In addition to collection for broodstock needs, fish are transported to various locations based on management priorities. Priorities for disposition of excess broodstock and non-hatchery species arriving at the Foster Trap are determined by balancing goals for natural production, the Spring Chinook Reintroduction/Outplant Program, hatchery management, and harvest opportunities; while ensuring that tribal obligations are satisfied. The Action Agencies and ODFW balance these goals with the physical limitations of the existing facility and the associated demands on hatchery personnel. In recent years, the majority of excess spring Chinook broodstock have been collected and transported to unseeded, historic habitat in efforts to re-establish natural production of spring Chinook (see Spring Chinook Reintroduction/Outplant Program in Section 2.10.2). In the South Santiam Basin, the Action Agencies and ODFW have transported fish collected at the Foster Fish Facility into several locations throughout the South Santiam subbasin, including Thomas Creek, Crabtree Creek, Wiley Creek, the Calapooia River, and the South Santiam River upstream of Foster Dam. Adult spring Chinook have not been transported into the Middle Santiam River or Quartzville Creek upstream of Green Peter Dam. A summary of these releases is found in Beidler and Knapp (2005).

Current general management goals for the spring Chinook reintroduction/outplant program are described in Table 2-20 below. Detailed protocols for disposition of excess hatchery broodstock, wild fish, and other species collected at Foster Fish Facility would be contained in the "Fish Disposition and Outplant Protocols" section of the Willamette FPMP. The FPMP would contain detailed, on-the-ground disposition protocols for all species of fish (clipped/unclipped) arriving at the Foster Fish Facility, including excess adult hatchery fish. Organized by date, it would specify priorities for disposition of wild/unclipped fish; and establish numerical goals (and perhaps minimum number of females) for release at each release site. These numerical goals would updated annually by the FPHM Committee.

Table 2-20 Management Goals for Fish Collected at the Foster Fish Facility.

Species	Destination	Target Number of Adult Fish *		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	600	300	30*
	South Santiam above Foster Dam (Riverbend and Gordon Road release sites)	As needed to meet unclipped goal	800 (in excess of broodstock collection goal of 4,000 females)	10
	Recycled into South Santiam below Foster Dam		None	0
	Crabtree, Thomas, and Wiley creeks	Any excess (approx. 100 to Crabtree; 150 to Thomas)	None	0
Winter steelhead	South Santiam above Foster Dam	0	All	100
	Remove from system	All	0	0
Summer steelhead	Broodstock	1,700	0	N/A
	Recycling below Foster	Any excess to brood	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

*These numbers reflect management targets, and are not intended to provide annual on-the-ground direction to personnel operating the fish facilities.

2.10.3.10 Research, Monitoring & Evaluation Questions Specific to South Santiam Spring Chinook Salmon Hatchery Program

The following RM&E questions are specific to the South Santiam Basin and the spring Chinook program. Any RM&E recommendations must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

1. Are mitigation requirements for habitat upstream of Green Peter being fully realized?
2. Evaluate benefits and effects of closure of Foster Fish Facility in July for maintenance.
3. Determine spawning timing and arrival date.
4. Management of Hatchery Strays on the spawning grounds?
5. Experiment with transporting brood at outplant protocol and compare survival; could reduce incidence of disease and necessity of treatment?
6. Evaluate stray rate among facilities for fish reared at South Santiam.
7. Investigate options for complete acclimation of all releases at South Santiam – why use direct release from Willamette into the South Santiam?

8. Could mechanisms for volitional release at South Santiam be designed into the Foster Facility?

2.10.4 McKenzie Spring Chinook Program

Proposed Action: **The Action Agencies would continue funding 50% of the operations and maintenance costs of McKenzie Hatchery, the primary rearing facility for the McKenzie Spring Chinook Program. The 1990 Mitigation Agreement with ODFW requires the USACE to fund production of a maximum of 80,800 pounds of juvenile spring Chinook to mitigate for the 4,060 Chinook salmon adults that spawned annually in habitat above Cougar and Blue River dams.**

Currently, the McKenzie Spring Chinook Program releases about 120,000 pounds (1,199,000 smolts) of spring Chinook smolts annually. The goals of the South Santiam Spring Chinook Program are to:

- Mitigate the loss of spring Chinook catch in sport and commercial fisheries caused by construction and operation of Cougar and Blue River Dams.
- Provide adequate fish to the hatchery to maintain the broodstock to perpetuate program goals as outlined in the ODFW McKenzie Subbasin Fish Management Plan (OAR 635-500-1666).
- Maintain a suitable conservation broodstock for ongoing and future population recovery efforts throughout the subbasin, including reintroduction efforts above the Cougar Dam and Reservoir complex.

Because of the conservation role of this hatchery program, the USACE proposes to operate the McKenzie spring Chinook program as an integrated hatchery program with conservation-oriented genetic protocol. McKenzie Hatchery produces the USACE entire mitigation requirement for spring Chinook salmon in the McKenzie subbasin. The McKenzie population of Upper Willamette River spring Chinook is one of the healthiest populations in the ESU. However, hatchery fish still comprise a large percentage of the run returning to the McKenzie. Poor attraction of adults to McKenzie Hatchery and poor trapping facilities at the Eugene Water & Electric Board's (EWEB) Leaburg Dam limit the USACE ability to prevent hatchery fish from spawning in the "wild fish sanctuary" established upstream of Leaburg Dam. The operation of the program is described in detail in the McKenzie spring Chinook HGMP (ODFW 2007a)

2.10.4.1 McKenzie Hatchery

Proposed Action: **The Action Agencies would operate and maintain McKenzie Hatchery. Timeframe: Immediate/ongoing.**

The Action Agencies propose to continue funding 50% of the operation and maintenance of McKenzie Hatchery as the primary hatchery facility used to meet its McKenzie spring Chinook mitigation requirements.

The majority of the broodstock for the McKenzie spring Chinook program is collected at McKenzie Hatchery, located on 16 acres adjacent to the McKenzie River near Leaburg, Oregon (Figure 2-10 below). The fish ladder at McKenzie Hatchery is located on the north bank of the McKenzie River. Broodstock enter the McKenzie Hatchery fish ladder from the river and enter a collection channel located at the downstream end of the holding ponds. From the holding ponds, the fish are crowded into the spawning building using a power crowder. A lift brings the fish up to two anesthetic tanks. The fish then can be handled for sorting, inoculation, transport, or placement into the holding ponds for broodstock. The adult holding ponds consist of two concrete ponds that are divided into two separate holding areas with aluminum fencing.

Figure 2-10 McKenzie Hatchery on the McKenzie River near Leaburg, Oregon.

2.10.4.2 Leaburg Dam (EWEB)

Proposed Action: The Action Agencies would develop and carry out alternatives to using the existing fish trap in the left bank ladder of Leaburg Dam as the primary means of reducing the incidence of spring Chinook on the spawning grounds. Alternatives include increasing homing and attraction back to McKenzie Hatchery; working with EWEB, ODFW, and other entities to construct a fish trap at Leaburg Dam, and consideration of reducing hatchery production in the McKenzie subbasin to reduce the number of returning hatchery fish. The Action Agencies would undertake this analysis within the context of the Phase III System Configuration Study for the McKenzie subbasin (see Section 2.12). Timeframe: Develop a strategy for reducing the incidence of hatchery strays on the spawning grounds within 6 months of issuance

The 2000 Willamette Hatchery Opinion (NMFS 2000a) required the USACE and ODFW to remove all adults that swim past the McKenzie Hatchery ladder at the Leaburg Dam fish ladder, which is owned by EWEB. However, the trap at Leaburg Dam consists of a blocked-off pool in the left bank ladder and does not meet ESA handling requirements. All fish have been manually netted out of the ladder, and during the peak of the passage season this trapping method results in unacceptable levels of take of natural origin adult UWR spring Chinook. Thus during peak passage, all Chinook have been allowed to pass over Leaburg Dam. EWEB recently constructed a new fish ladder on the right bank without a fish trap. This allows all fish to pass unimpeded over Leaburg Dam via this ladder throughout the run. A fish trap is needed on both ladders in order to achieve the objective of removing 100% of the hatchery fish at Leaburg Dam.

2.10.4.3 Broodstock

Proposed Action: The Action Agencies would continue use of McKenzie (stock 023) spring Chinook. Timeframe: Ongoing/immediate.

The Action Agencies propose to continue using McKenzie spring Chinook (stock 023) to meet its mitigation responsibilities.

Proposed Action: The Action Agencies would collect the majority of McKenzie spring Chinook broodstock at McKenzie Hatchery; supplement the unclipped portion with fish from Leaburg Dam, if necessary. Timeframe: Ongoing/immediate.

The majority of spring Chinook for the McKenzie spring Chinook program is collected at McKenzie Hatchery. Fish are attracted into the fish ladder on the left bank of the McKenzie River. There is no channel-spanning barrier to guide fish into the ladder. In 2006, implementation of new protocols for incorporation of unmarked fish into the brood required that ODFW collect a portion of the unclipped broodstock at Leaburg Dam.

The Action Agencies propose to continue collecting McKenzie spring Chinook (stock 023) broodstock at the McKenzie Hatchery, and potentially at Leaburg Dam to ensure incorporation of natural-origin fish into the brood. Any changes in broodstock collection location, including collection at Cougar Dam, would be discussed in the FPHM Committee.

Proposed Action: The Action Agencies would continue to collect broodstock throughout the run to ensure the hatchery population is similar to the naturally spawning population. Timeframe: Ongoing/immediate.

Spring Chinook adults returning to McKenzie Hatchery are collected throughout the entire run between May and October and mixed in the dividable holding pond where they are held until ripening.

Proposed Action: The Action Agencies would incorporate an appropriate percentage of natural-origin fish incorporated into the broodstock to ensure the hatchery population is similar to the naturally spawning population.

The Action Agencies and ODFW would increase the percentage of natural origin fish into the McKenzie spring Chinook broodstock in order to achieve the management goal of operating the program as an integrated program with a conservation-oriented genetic protocol. In the short-term, NMFS recommends incorporating more natural origin fish into the broodstock as possible, approaching 20% natural origin fish (NMFS 2000a). The percentage of non-adipose, fin-clipped fish incorporated into the brood would follow the guidance in Table 2-21 below. The Action

Agencies would modify these guidelines based on recommendations from the HSRG and/or the FPHM Committee.

Table 2-21 Proposed Broodstock Collection Guidelines for the McKenzie Spring Chinook Hatchery Program.

McKenzie Spring Chinook	Hatchery Broodstock			Above Cougar and Trail Bridge Dams	
Returns of Chinook to South Santiam (H & W) as indexed by May 31 Willamette Falls Counts	Maximum percent wild fish in hatchery broodstock (900 fish goal)	Corresponding maximum number wild fish in broodstock	Maximum percent of wild population taken for brood	Wild fish	Hatchery fish
<30,000 (low run)	20	160	10-20	Ensure wild fish incorporated into broodstock	As needed to have minimum spawning escapement of at least 500 fish
3,000-50,000 (medium run)	30	240	10-20	No outplanting of wild fish, pass over Leaburg Dam	
>50,000 (high run)	40	320	10-20		

2.10.4.4 Adult Transport, Holding, & Prophylactic Treatment

Proposed Action: The Action Agencies would continue to hold and spawn McKenzie spring Chinook on-site at the McKenzie Hatchery. Timeframe: Ongoing/immediate.

Spawning and mating occurs on site at McKenzie Hatchery; no transport of brood is necessary. Broodstock are held in the dividable adult holding pond at McKenzie Hatchery until spawning. Brood are injected with antibiotics and treated with hydrogen peroxide for fungus control. The Action Agencies do not propose any changes to the holding protocol for broodstock unless minor improvement can be made to the existing holding pond.

2.10.4.5 Mating

Proposed Action: The Action Agencies would continue to use random spawning protocol with a 1:1 male-to-female ratio. Timeframe: Ongoing/immediate.

Adults used for brood are mixed as they return to the hatchery and are randomly selected for each spawn. The Action Agencies do not propose any changes to the spawning protocol, unless results of RM&E indicate that spawning is not truly random with respect to run representation, age, and size of broodstock.

2.10.4.6 Incubation & Rearing

Proposed Action: The Action Agencies would continue to incubate and rear all McKenzie spring Chinook at the McKenzie Hatchery. Timeframe: Ongoing/immediate.

The Action Agencies do not propose any changes to the incubation and rearing protocol, with the exception of changes necessary to accommodate experimental changes in release size or timing. All fish are reared from egg to smolt at McKenzie Hatchery. Button up happens at 1500-1550 TUs, and ponding normally occurs from mid-December through January. About 2.2 million eggs are taken annually. Fry to smolt survival is typically greater than 96%.

2.10.4.7 Marking

Proposed Action: The Action Agencies would continue to adipose fin-clip and otolith mark all McKenzie spring Chinook at the McKenzie Hatchery. Timeframe: Ongoing/immediate.

The Action Agencies propose to continue the current practice of adipose fin-clipping and otolith marking all McKenzie Hatchery spring Chinook.

Proposed Action: The Action Agencies would insert coded wire tags into all juvenile hatchery fish in addition to current practice of adipose fin-clipping and otolith marking. Timeframe: Purchase CWTs for all fish released in experimental releases in FY 2008. Include purchase of CWTs for all McKenzie releases in FY 2009 budget request and out years.

In addition to the current practice of adipose fin-clipping and otolith marking all hatchery releases, the Action Agencies propose to insert CWTs into all hatchery releases. Tag codes should be assigned according to releases in order to evaluate alternative release strategies.

2.10.4.8 Acclimation & Release

Proposed Action: The Action Agencies would continue releasing all McKenzie spring Chinook at McKenzie Hatchery, experiment with acclimation techniques that could improve homing to McKenzie Hatchery. Timeframe: Ongoing/immediate.

The Action Agencies propose to continue releasing smolts from McKenzie Hatchery and allowing for volitional release (Table 2-22). There is no acclimation procedure, as all fish are reared at McKenzie Hatchery. The Action Agencies support ODFW's fingerling release into Mohawk River, pending annual recommendation and coordination with the FPHM committee.

Table 2-22 Proposed Release Schedule for McKenzie Spring Chinook.

Life Stage	Release Location	Release Date	Mean Size at Release (fish per lb)	Number of Fish Released	Total Pounds Released
Fingerling	Mohawk River	June	100	75,000	750
Yearling	McKenzie Hatchery	November	8	350,000	43,750
1+ Yearling	McKenzie Hatchery	February	12	400,000	33,333
1+ Yearling	McKenzie Hatchery	March	11	449,000	40,818
TOTALS				1,199,000	118,651

Proposed Action: The Action Agencies would examine the potential impacts of reducing production at McKenzie Hatchery to decrease the incidence of hatchery fish spawning in the area above Leaburg Dam, which is a wild fish sanctuary. Timeframe: Examine alternatives with ODFW within 1 year of issuance.

Should reintroduction efforts above Cougar Dam produce a self-sustaining population of spring Chinook, then the Action Agencies would propose to further reduce mitigation production.

2.10.4.9 Spring Chinook Reintroduction/Outplant Program & Disposition of Fish Arriving at McKenzie Hatchery

Several species of fish arrive at McKenzie Hatchery throughout the year, including spring Chinook and non-native hatchery summer steelhead. In addition to collection for broodstock needs, fish are transported to various locations based on management priorities. Priorities for disposition of excess broodstock and non-hatchery species arriving at the McKenzie Hatchery are determined by balancing goals for natural production, the Spring Chinook Reintroduction/ Outplant Program, hatchery management, and harvest opportunities; while ensuring that tribal obligations are satisfied. The Action Agencies and ODFW balance these goals with the physical limitations of the existing facility and the associated demands on hatchery personnel. In recent years, the majority of excess spring Chinook broodstock have been collected and transported to unseeded, historic habitat in efforts to re-establish natural production of spring Chinook (see Spring Chinook Reintroduction/Outplant Program in Section 2.10.2). In the McKenzie subbasin, the Action Agencies and ODFW have transported fish collected at the McKenzie Hatchery into several locations throughout the McKenzie subbasin, including the Mohawk River, the McKenzie River upstream of Trail Bridge Dam (owned by EWEB), and the South Fork McKenzie River upstream of Cougar Dam. A summary of these releases is found in Beidler and Knapp (2005).

Current general management goals for the spring Chinook reintroduction/outplant program are described in Table 2-23 below. Detailed protocols for disposition of excess hatchery broodstock, wild fish, and other species collected at McKenzie Hatchery (and Cougar Dam) would be contained in the “Fish Disposition and Outplant Protocols” section of the Willamette FPMP. The FPMP would contain detailed, on-the-ground disposition protocols for all species of fish (clipped/unclipped) arriving at McKenzie Hatchery, including excess adult hatchery fish. Organized by date, it would specify priorities for disposition of wild/unclipped fish; and establish numerical goals (and perhaps minimum number of females) for release at each release site. These numerical goals would updated annually by the FPHM Committee.

Table 2-23 Management Goals for Fish Collected at McKenzie Hatchery.

Species	Destination	Target Number of Adult Fish *		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	640	160	10-20
	South Fork above Cougar Dam	3,000 (short-term goal of 2,000)	None at this time given downstream survival uncertainty; long-term goal is to use wild fish.	0
	McKenzie above Trailbridge	120 *	None at this time	
	Mohawk River	100	0	0
	Remove from system	Excess to brood and outplanting	0	0
Summer steelhead	Recycling below Leaburg	All	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

* Future outplants would come from fish passed over Trailbridge via ladder or trap and haul by EWEB.

2.10.4.10 Research, Monitoring & Evaluation Needs Specific to McKenzie Spring Chinook Salmon Hatchery Program

The following RM&E questions are specific to the McKenzie Basin and the spring Chinook program. Any RM&E recommendations must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

1. Experiment with acclimation procedures (chemical/scent tracers) at McKenzie Hatchery to increase homing and decrease straying onto spawning grounds.
2. Evaluate production levels at McKenzie Hatchery to decrease the incidence of hatchery spawners on the spawning grounds.

2.10.5 Middle Fork Willamette Spring Chinook Hatchery Program

Proposed Action: **The Action Agencies would propose to continue funding 83.75% of the operations and maintenance costs of Willamette Hatchery, the primary rearing facility for the Middle Fork Willamette spring Chinook program. The 1990 Mitigation Agreement with ODFW requires the USACE to fund production of a maximum of 235,000 pounds of juvenile spring Chinook and steelhead to mitigate for lost production above Dexter, Lookout Point, and Hills Creek Dams.**

Currently, the Middle Fork Willamette spring Chinook program releases about 120,000 pounds (1,199,000 smolts) of spring Chinook smolts annually. The goals of the Middle Fork spring Chinook program are to:

- Mitigate the loss of spring Chinook catch in sport and commercial fisheries caused by construction and operation of Dexter, Lookout Point, and Hills Creek Dams.
- Provide adequate fish to the hatchery to maintain the broodstock to perpetuate program goals as outlined in the Middle Fork Willamette chapter of the FPMP (OAR 635-500-1666).
- Maintain a suitable conservation broodstock for ongoing and future population recovery efforts throughout the subbasin, including reintroduction efforts above the Dexter, Lookout Point, and Hills Creek Dams.

Because of the conservation role of this hatchery program, the USACE proposes to operate the Middle Fork Willamette spring Chinook program as an integrated hatchery program with conservation-oriented genetic protocol. Willamette Hatchery produces the USACE's entire mitigation requirement for spring Chinook salmon in the Middle Fork Willamette. Very few natural-origin adults have returned to the Middle Fork Willamette (i.e., less than 100 fish), and the hatchery program in the Middle Fork Willamette subbasin would be used to rebuild the naturally-spawning population. The operation of the program is described in detail in the Middle Fork Willamette spring Chinook HGMP (ODFW 2007a) and would be described in the Willamette FPMP (see Section 2.7).

2.10.5.1 Dexter Pond Fish Facility

Proposed Action: The Action Agencies would operate, maintain, and possibly rebuild the Dexter Pond Fish Facility. Timeframe: Immediate/ongoing. Preliminary designs for rebuilding the facility were completed in 2005 and are described in the South Willamette Valley Fish Facilities Improvements Report (McMillen Engineering 2005). The conceptual timeline for reconstruction of Dexter Ponds Fish Facility is described in Section 2.12.

The Dexter Pond Facility, located at the base of Dexter Dam, is a satellite facility associated with Willamette Hatchery and is used to capture adult fish, provide juvenile rearing capacity, and serve as an acclimation facility for juvenile releases (Figure 2-11). In addition, both summer and winter steelhead are reared at this facility for a short period of time. All Middle Fork Willamette spring Chinook salmon broodstock are collected at Dexter Pond and transported to a holding pond at Willamette Hatchery until spawning.

Figure 2-11 Dexter Pond Fish Facility and Adult Pre-sort Holding Pond.

The facility was designed as a collection and acclimation facility and was not designed to accommodate sorting adult fish that would be later released to spawn naturally. Migrating adults are blocked by Dexter Dam and guided to the fish ladder entrance. The broodstock collection facility consists of a fish ladder, pre-sort holding pool, two fish locks and brails, an anesthetic tank, and a sorting table. Sorted fish are routed via PVC tubes to various locations.

The Action Agencies would possibly build a new fish collection facility at Dexter Pond that complies with NMFS criteria for upstream passage/collection facilities. The facility would provide adequate attraction of fish into the trap, automated sorting (when possible), and water-to-water transfer of fish into transport trucks. The facility would also serve as an effective juvenile acclimation facility that allows for volitional release. In the short term, the USACE proposes to continue operating Dexter Pond in its current condition while it completes designs for a new facility.

2.10.5.2 Willamette Hatchery

Proposed Action: The Action Agencies would operate and maintain the Willamette Hatchery. Timeframe: Immediate/ongoing.

The Willamette Hatchery is situated on 75 acres near the town of Oakridge, Oregon. The hatchery is composed of the original trout hatchery, situated near the entrance and the old salmon hatchery which is immediately adjacent to the trout facility (Figure 2-12). Willamette Hatchery is also used for rearing South Santiam spring Chinook, summer steelhead, and rainbow trout. Willamette Hatchery has 1,005 total incubators, which allow for the incubation of 9 million eggs. All incubators are equipped with alarms. All adult spring Chinook are spawned under a covered deck adjacent to the earthen channel adult holding pond at Willamette Hatchery

Figure 2-12 Willamette Hatchery Near Oakridge, Oregon.

2.10.5.3 Broodstock

Proposed Action: The Action Agencies would continue use of Middle Fork (stock 022) spring Chinook. Timeframe: ongoing/immediate. Timeframe: ongoing/immediate.

Broodstock for the Middle Fork spring Chinook (stock 022) were derived from the local wild population. Because the Middle Fork spring Chinook Program is both a mitigation and conservation hatchery program, this is the most suitable stock to propagate.

Proposed Action: The Action Agencies would continue collecting all Middle Fork spring Chinook broodstock at Dexter Pond Fish Facility. Timeframe: ongoing/immediate.

Dexter Ponds is the only location in the Middle Fork for obtaining Middle Fork Willamette Spring Chinook. Fall Creek Dam is located on Fall Creek, a tributary of the Middle Fork Basin.

Proposed Action: The Action Agencies would collect broodstock throughout the run (including the early part of the season) to ensure the hatchery population is similar to the naturally spawning population. Timeframe: Develop plan for initiating early season collection for 2008 brood year. Annual review by the FPHM Committee.

The Action Agencies propose opening the trap periodically at the Dexter Pond Fish Facility in the early part of the season to ensure collection of broodstock and fish for outplanting during the early part of the season (Table 2-24). Currently, fish are held in the Middle Fork Willamette River downstream of Dexter Dam until the trap opens in mid-June. These fish are assumed to mix while holding, such that that when the trap is opened in June, the sample is representative. However, this assumption has never been tested.

Proposed Action: The Action Agencies would incorporate an appropriate percentage of natural origin fish incorporated into the broodstock to ensure the hatchery population is similar to the naturally spawning population. Timeframe: ongoing/immediate.

The percentage of non-adipose, fin-slipped fish incorporated into the brood would follow the guidance in Table 2-24 (below). Returning adults are collected and spawned for broodstock. At this time the program goal is to spawn 835 females and 835 males (or about 1,670 fish total), as needed for egg production. Acclimation and volitional release at Dexter Pond minimizes the risk of returning hatchery adults straying onto the spawning grounds or into other subbasins.

Table 2-24 Proposed Broodstock Collection Guidelines for the Middle Fork Spring Chinook Hatchery Program.

Middle Fork Spring Chinook	Hatchery Broodstock			Above Dexter, Lookout Point and Hills Creek Dams	
Returns of Chinook to Dexter Pond (hatchery & wild) as indexed by May 31 Willamette Falls Counts	Maximum percent wild fish in hatchery broodstock (1600 fish goal)	Corresponding maximum number wild fish in broodstock	Maximum number of wild pop. taken for brood	Wild fish	Hatchery fish
<30,000 (low run)	30	480	100*	Ensure wild fish incorporated into broodstock	As needed to have minimum spawning escapement of at least 500 fish
3,000-50,000 (medium run)	30	480	100*	All after brood needs fulfilled	
>50,000 (high run)	30	480	100*		

*Wild fish production is so poor that if all of the wild fish captured are taken for broodstock, it would be far less than the 30% wild fish in the broodstock. This criterion would be reevaluated if and when wild fish returns increase due to reintroduction efforts.

2.10.5.4 Adult Transport, Holding, & Prophylactic Treatment

Proposed Action: The Action Agencies would continue to transfer adult Middle Fork spring Chinook collected at Dexter Ponds to Willamette Hatchery for holding and spawning. The Action Agencies would investigate improvements to the collection/crowding location at Dexter Dam. Timeframe: immediate/ongoing.

The original adult holding ponds at Dexter Pond are no longer used. All adults collected at Dexter are hand-loaded onto trucks to be recycled downstream into the fishery, released upstream of Lookout Point Dam, or transported to Willamette Hatchery where they are held until spawning. The adult Chinook holding facility at Willamette Hatchery was constructed in 1940 in a former side channel of Salmon Creek and still resembles a cobble-bottomed river channel. It is shaded by trees and is an excellent adult Chinook holding facility. Flow rate through the channel is approximately 1,500 gpm. The collection of adults initially at Dexter Dam (before transporting to Willamette hatchery) is difficult in its present configuration.

2.10.5.5 Mating

Proposed Action: The Action Agencies would continue to use random spawning protocol with a 1:1 male-to-female ratio. Timeframe: immediate/ongoing.

The Action Agencies do not propose any changes to the spawning protocol, unless results of RM&E indicate that spawning is not truly random with respect to run representation, age, and size of broodstock.

2.10.5.6 Incubation & Rearing

Proposed Action: The Action Agencies would continue to incubate and rear all Middle Fork spring Chinook at the Willamette Hatchery. Timeframe: immediate/ongoing.

The Action Agencies do not propose any changes to the incubation and rearing protocol, with the exception of changes necessary to accommodate experimental changes in release size or timing.

About 4 million eggs are collected annually at Willamette Hatchery. The majority of production is reared at the hatchery before being transferred to Dexter Ponds (1.3 million fish at 100/pound in June and 207,000 fish at 25/pound in November); 90,000 are retained at Willamette Hatchery until release into Fall Creek in February. Button up happens at 1700 TUs (approximately 1,400 fish/pound), and ponding normally occurs in late December. Eyed to ponding survival is typically greater than 96%. Willamette Hatchery also rears South Santiam spring Chinook, summer steelhead, and rainbow trout.

2.10.5.7 Marking

Proposed Action: The Action Agencies would continue to adipose fin-clip and otolith mark all Middle Fork Willamette spring Chinook at Willamette Hatchery. Timeframe: immediate/ongoing.

The Action Agencies propose to continue the current practice of adipose fin-clipping and otolith marking all Middle Fork spring Chinook.

Proposed Action: The Action Agencies would insert coded wire tags into all juvenile hatchery fish in addition to current practice of adipose fin-clipping and otolith marking. Timeframe: include purchase of CWTs for all Middle Fork releases in FY 2009 budget request and out years.

In addition to the current practice of adipose fin-clipping and otolith marking all hatchery releases, the Action Agencies propose to insert CWTs into all hatchery releases. Tag codes should be assigned according to releases in order to evaluate alternative release strategies.

2.10.5.8 Acclimation & Release

Proposed Action: The Action Agencies would continue acclimating and releasing the majority of Middle Fork Willamette spring Chinook at Dexter Pond Fish Facility. Timeframe: immediate/ongoing.

The Action Agencies propose to continue acclimating and releasing the majority of smolts at Dexter Pond and allowing for volitional release (Table 2-25 below). The Action Agencies would provide flows that allow acclimation and volitional release whenever possible until a new facility is built that functions throughout a wider range of river levels. The Action Agencies support continuing the release of fingerlings in Fall Creek to mitigate for failed downstream passage at Fall Creek Dam.

Table 2-25 Proposed Release Schedule for Middle Fork Spring Chinook.

Life Stage	Release Location	Release Date	Mean Size at Release (fish per lb)	Number of Fish Released	Total Pounds Released
Unfed Fry	Various STEP locations	Dec		10,000	
Yearling	MF Willamette at Dexter Ponds	Nov	8	300,000	37,500
1+ Yearling	MF Willamette at Dexter Ponds	Feb	11	538,000	48,909
	MF Willamette at Dexter Ponds	Mar	9	657,240	73,027
1+ Yearling	Below Fall Creek Reservoir	Feb	9	90,000	10,000
1+ Yearling	*Columbia River**	*March*	*12*	*855,000**	*71,250**
TOTALS	---	---	---	1,595,240	169,436

* Refer to the spring Chinook HGMP for more information, not included in total.

2.10.5.9 Spring Chinook Reintroduction/Hatchery Outplant Program

Several species of fish arrive at the Dexter Ponds Facility throughout the year, including hatchery and wild UWR spring Chinook and non-native hatchery summer steelhead. In addition to collection for broodstock needs, fish are transported to various locations based on management priorities (Table 2-26 below). Priorities for disposition of excess broodstock and non-hatchery species arriving at the Dexter Trap are determined by balancing goals for natural production, the Spring Chinook Reintroduction/ Outplant Program, hatchery management, and harvest opportunities; while ensuring that Tribal obligations are satisfied. The Action Agencies and ODFW balance these goals with the physical limitations of the existing facility and the associated demands on hatchery personnel. In recent years, the majority of excess spring Chinook broodstock have been collected and transported to unseeded, historic habitat in efforts to re-establish natural production of spring Chinook (see Spring Chinook Reintroduction/Outplant Program in Section 2.10.2). In the Middle Fork subbasin, adult spring Chinook have been released in the North Fork Middle Fork upstream of Lookout Point Reservoir, the Middle Fork Willamette upstream of Hills Creek Reservoir, and Salt Creek. Some Chinook salmon have been released into the Coast Fork Willamette Basin. A summary of these releases is found in Beidler and Knapp (2005).

Table 2-26 Management Goals for Fish Collected at Dexter Ponds Fish Facility.

Species	Destination	Target Number of Adult Fish *		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	1,200	500	100 *
	North Fork, Middle Fork Willamette	2,000	Any in excess of broodstock	
	Salt Creek	1,000	0	
	Middle Fork above Hills Creek Dam	3,000	0	
Summer Steelhead	Recycle – Middle Fork Willamette below Dexter Dam	All	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

Detailed protocols for disposition of excess hatchery broodstock, wild fish, and other species collected at Dexter Pond would be contained in the "Fish Disposition and Outplant Protocols" section of the Willamette FPMP. The FPMP would contain detailed, on-the-ground disposition protocols for all species of fish (clipped/unclipped) arriving at the Dexter Pond Fish Facility, including excess adult hatchery fish. Organized by date, it would specify priorities for disposition of wild/unclipped fish and establish numerical goals (and perhaps minimum number of females) for release at each release site. These goals would updated annually by FPHM Committee.

2.10.5.10 Research, Monitoring & Evaluation Needs for the Middle Fork Spring Chinook Salmon Hatchery Program

RM&E related to the Middle Fork Chinook salmon hatchery program must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

2.10.6 Upper Willamette Summer Steelhead Hatchery Program

The Upper Willamette Summer Steelhead Hatchery Program is managed to provide fish for sport fisheries and to replace lost fisheries caused by habitat and passage loss/degradation in the Willamette Basin and other lower Columbia basins. Summer steelhead are not native to the Willamette Basin upstream of Willamette Falls, and winter steelhead were historically not found in the Willamette Basin upstream of the Santiam River subbasin. ODFW first introduced summer steelhead into the upper Willamette Basin in the latter 1960s. Initially summer steelhead were brought into the South Santiam River as mitigation for lost winter steelhead production in areas inundated by the Foster and Green Peter reservoirs. This hatchery program was expanded to include annual smolt releases into the North Santiam, McKenzie, Middle Fork Willamette, and Molalla rivers as well, with the Molalla summer steelhead program being discontinued in 1997.

Winter steelhead were not used for mitigation in the South Santiam system for several reasons: (1) constraints on the ability to raise a quality smolt in the hatchery environment within the necessary timeframe; (2) because trap-and-haul and bypass facilities were incorporated into the dams, it was believed that UWR (winter) steelhead production above the reservoirs would continue to occur as it had in the past; and (3) fisheries managers wanted to develop expanded steelhead angling opportunities.

Summer steelhead are reared at a variety of hatchery facilities throughout the state. Production of summer steelhead in the Willamette Basin is funded from many other sources, including ODFW's Sport Fish Restoration Program and general fund, NMFS, Portland General Electric, and BPA. Details regarding funding allocations are provided in Section 1.3 of the Upper Willamette Summer Steelhead HGMP (ODFW 2004a).

Proposed Action: The Action Agencies would continue current operations, production schedules, and releases as described in the Upper Willamette Summer Steelhead HGMP (ODFW 2004a) and in this section below. However, the Action Agencies propose to work with ODFW and the FPHM Committee of WATER to develop potential changes in the release strategies or production levels that could reduce impacts of the summer steelhead program on wild winter steelhead, such as scatter-planting smolts to increase harvest opportunities.

Proposed Action: The Action Agencies would, to the extent feasible (given infrastructure constraints), remove "non-migrants" from hatchery release groups to reduce residualism of fish that do not volitionally emigrate and potentially reduce adverse interactions with rearing winter steelhead.

Proposed Action: Beginning no later than 2008, the Action Agencies would scale back summer steelhead recycling efforts in the North Santiam Basin where the potential for adverse interactions with ESA-listed UWR winter steelhead are most significant. This would include incorporating the recycling protocol into the North Santiam/Minto Pond FPMP.

Proposed Action: **The Action Agencies would assess the recycling program in the South Santiam basin to determine the extent to which early cessation of the recycling program would alleviate impacts to winter steelhead populations and impact fishery opportunities. The Action Agencies would incorporate the current recycling protocol into the South Santiam/Foster Dam FPMP. The Action Agencies would incorporate any changes in recycling protocol into the FPMP and carry out such changes beginning in 2009.**

Proposed Action: **Conduct short-term RM&E (in collaboration with other funding entities) to further define effects of the Upper Willamette Summer Steelhead Program on ESA-listed species. RM&E activities would focus on the following objectives:**

- **Determine the extent of natural production of summer steelhead (potentially by collecting genetic sampled from juvenile steelhead).**
- **Determine the extent to which juvenile summer steelhead and winter steelhead compete for resources, and ultimately determine if naturally produced summer steelhead are impacting productivity of winter steelhead.**
- **Continue monitoring returns of summer steelhead and the incidence of summer steelhead spawning in the wild.**
- **RM&E activities would be incorporated into the overall RM&E plan.**

Proposed Action: **Convene an interagency Summer Steelhead Working Group (as a subcommittee of the WATER FPHM Committee) to discuss options for long-term management of the summer steelhead program in light of ESA requirements and harvest goals. This group should seek input from non-governmental entities, such as sport fishing groups, and contain representation from other funding entities. This effort should also be informed by the Columbia Basin Hatchery Reform Project. The Summer Steelhead Working Group would:**

- **Discuss feasibility of implementing changes to the program as identified in the HGMP.**
- **Review results from the Columbia Basin Hatchery Reform Project.**
- **Review additional RM&E results that would inform priorities for shifts in management.**
- **Prioritize implementation of hatchery reform actions.**
- **Strive to develop a reform implementation plan that all funding entities agree to implement. If the entities cannot agree, then the USACE would propose reform actions for its portion of the production and reinitiate consultation.**

- **The Action Agencies would begin programming funding for hatchery reform efforts according to the implementation plan and implement actions as fund become available.**

Proposed Action: **The Action Agencies would set a 5-year check-in evaluation to verify with the Services that the implementation plan meets the requirements of the ESA. Should the plan (and any activities conducted to date) not be sufficient to avoid jeopardy to the UWR winter steelhead and spring Chinook ESUs, then the Action Agencies would reinitiate consultation. The following section summarizes the current program, which is described in detail in the Upper Willamette Summer Steelhead HGMP (ODFW 2004a).**

2.10.6.1 Current Summer Steelhead Hatchery Program: Broodstock, Production & Release

Broodstock

The Upper Willamette Summer Steelhead Program uses Skamania summer steelhead (stock 024), originating with eggs collected on the Washougal River. Beginning in 1973, all brood have been collected at the Foster Dam Fish Facility associated with South Santiam Hatchery. Only known hatchery fish are used for broodstock propagation.

Fish Disposition

Surplus hatchery fish are recycled through the downstream fishery until October when fish arriving at the collection facilities are removed from the system.

Collection Goals

Adult collection goals vary depending upon annual broodstock needs. To satisfy a cumulative smolt production goal of approximately 900,000, the current green-egg take goal is approximately 1.8 million (2003-2004 ODFW Hatchery Production schedules) from returning hatchery fish. From 1994 to 2002, the average number of broodstock collected annually was 455 males and 550 females, resulting in an average egg take of 1,849,000 (see Table 7.4.2 in the South Santiam HGMP (ODFW 2008b)).

Rearing Strategies

While all broodstock collection occurs at South Santiam Hatchery, summer steelhead are reared at several hatcheries throughout Oregon. The USACE-funded hatcheries include South Santiam, Marion Forks, McKenzie, Leaburg, and Willamette (see Table 1.5 in the South Santiam HGMP (ODFW 2008b) fish are often moved throughout their lifecycle.

Acclimation & Release

Acclimation and release procedures vary among basins and are described in Chapters 9 and 10 of the HGMP. All releases are adipose-fin clipped. Table 2-27 below summarizes the release levels for each major subbasin in the Willamette Basin as described in the HGMP (ODFW 2007a, 2008a, 2008b).

Table 2-27 Proposed Annual Fish Release Levels by Life Stage and Location.

Life Stage	Release Location	Annual Release Level (maximum number)
Yearling	North Santiam River/Minto Pond (April Release)	161,500
	South Santiam River (April Release)	144,000
	Willamette River at Eugene (April Release)	42,000
	Middle Fork Willamette (April Release)	115,000
	McKenzie River (April Release)	108,000

2.10.6.2 Hatchery Management Goals

Specific adult summer steelhead harvest goals are established in ODFW subbasin management plans and are listed in Table 1.7 of the Upper Willamette Summer Steelhead HGMP (ODFW 2004a). The summer steelhead program is managed as a segregated program (or isolated harvest), with the intent that summer steelhead would not spawn in the wild or adversely interact with ESA-listed species, such as UWR winter steelhead and UWR spring Chinook.

2.10.7 Rainbow Trout Mitigation Program

The goal of this program is to mitigate for trout harvest opportunities lost as a result of the construction and operation of Big Cliff, Detroit, Green Peter and Foster in the Santiam River subbasin, Fern Ridge in the Long Tom River subbasin, Blue River and Cougar in the McKenzie River subbasin, and Fall Creek, Lookout Point, Dexter, Dorena, Cottage Grove and Hills Creek in the upper Willamette River subbasin. The mitigation agreement calls for the production of no more than 277,000 pounds of *Oncorhynchus mykiss* (rainbow trout and steelhead) and *O. clarki* (cutthroat trout) annually. Rainbow trout comprise approximately 243,300 pounds of this amount. A stock of cutthroat that originated from the Long Tom River was discontinued because of poor performance. Cutthroat trout are no longer produced as part of the mitigation agreement.

Proposed Action: The Action Agencies would continue current operations, production schedules, and releases as described in the Upper Willamette Rainbow HGMP (ODFW 2005a) and summarized in Section 2.10.8.1.

Proposed Action: The Action Agencies would work with ODFW to develop a strategy for long term production of fish to meet the USACE's mitigation responsibility (i.e., including addressing Infectious Haematopoietic Necrosis (IHN) virus outbreaks at Leaburg Hatchery). Alternatives include installation of an ultraviolet filtration system at Leaburg, shifting production of rainbow trout to other facilities, and purchasing a portion (or all) of the fish required to meet the mitigation requirement.

Proposed Action: The Action Agencies would conduct short-term RM&E (in collaboration with other funding entities) to further define effects of the Upper Willamette Rainbow Trout Program on ESA-listed species. RM&E activities would focus on the following objectives:

- **Determine the spatial distribution of rainbow trout after release. Angler evidence indicates that releases migrate within basins to areas used heavily by rearing UWR spring Chinook.**
- **Determine the impact of rainbow trout predation on juvenile ESA-listed species in 2008. The original study involved several assumptions that were likely invalid. Combine this study effort with results regarding the spatial and temporal distribution of rainbow trout. Use these results to develop changes in management strategy for rainbow trout, including potential changes to harvest regulations.**
- **RM&E activities would be incorporated into the overall RM&E plan.**

Proposed Action: **The Action Agencies would convene an interagency Rainbow Trout Working Group (as a subcommittee of the WATER FPHM Committee) to discuss options for long-term management of the rainbow trout program in light of ESA-requirements and harvest goals. This group should seek input from non-governmental entities, such as sport fishing groups, and contain representation from other funding entities. The group would:**

- **Discuss feasibility of implementing changes to the program as identified in the HGMP or to change the type and species of release to meet the USACE mitigation responsibility.**
- **Review results from the Columbia Basin Hatchery Reform Project.**
- **Review additional RM&E results that would inform priorities for shifts in management.**
- **Prioritize implementation of reform actions, including changes to harvest regulations.**
- **The Action Agencies would begin programming funding for hatchery reform efforts according to the implementation plan and implement actions as fund become available.**

Proposed Action: **The Action Agencies would set a 5 year check-in evaluation to verify with the Services that the implementation plan meets ESA requirements. Should the plan (and any activities conducted to date) not be sufficient to avoid jeopardy to the UWR winter steelhead and spring Chinook ESUs, then the Action Agencies would reinitiate consultation. The following section summarizes the current program, which is described in detail in the Upper Willamette Rainbow Trout HGMP (ODFW 2005a).**

2.10.7.1 Current Rainbow Trout Hatchery Program: Production Levels, Rearing & Releases

Broodstock

The program uses Cape Cod stock (072) rainbow trout, an out-of-basin stock that was selected because of its spawn timing. The Cape Cod stock differs from native rainbow trout in the Willamette Basin in that the Cape Cod stock spawn in the fall (November-December), whereas native rainbow trout spawn in the spring (March-May). Also, it has been theorized that the genetic tendency for migration is more suppressed in the Cape Cod stock (Moring 1975) than in natural stocks. The broodstock is composed entirely of hatchery fish; all brood are maintained at Roaring River Hatchery. No wild trout are included in the broodstock.

Rearing and Incubation

Rainbow trout are currently raised primarily at two USACE-funded hatcheries – Leaburg Hatchery on the McKenzie River and Willamette Hatchery in the Middle Fork Willamette Basin. Rainbow trout are also reared at Roaring River Hatchery, which is funded by ODFW.

Release

Rainbow trout are released throughout the entire Willamette Basin, primarily at a size of three to four fish per pound (Table 2-28). Section 10 of the HGMP describes the releases in more detail (ODFW 2005a). All fish released into water bodies inhabited by ESA-listed species are adipose fin-clipped. Excess fish are released as fingerlings into lakes.

Table 2-28 Releases of Rainbow Trout and Presence of ESA-listed Species in Release Areas.

South Willamette Area						
Waterbody	**ODFW Waterbody Code**	**ESA-listed Fish Present [2]**	**Mark**	**Legal-size releases [3]**	**Fingerling Releases [4]**	**Total Releases**
Alton Baker Canal	0200100000	ChS		17000		17000
Big Cliff Res.	0270600000	ChS		5500		5500
Blue River	0201520000	BuT, ChS		6500		6500
Blue River Res.	0271600000	---		13000		13000
Breitenbush R.	0201110000	ChS		20000		20000
Carmen Res.	0270900000	---		24000		24000
Clear Lk.	0208600000	---		29000		29000
Cottage Grove Pd.	0263900000	---		5000		5000
Cottage Grove Res.	0270000000	---		16500		16500
Creswell Pd.	0250000000	---		4500		4500
Detroit Res.	0270200000	ChS		124500	300000	424500
Dexter Res. [1]	0270500000	ChS		19800		19800
Dorena Res. [1]	0270100000	---		18300		18300
E E Wilson Pd.	0251200000	---		12125		12125
Fall Cr.	0200310000	ChS		10000		10000

South Willamette Area						
Waterbody	**ODFW Waterbody Code**	**ESA-listed Fish Present [2]**	**Mark**	**Legal-size releases [3]**	**Fingerling Releases [4]**	**Total Releases**
Foster Res.	0271400000	ChS. StW	ad	43500		43500
Freeway Lk. E.	0230400000	ChS		4350		4350
Green Peter Res.	0271500000	ChS		22000		22000
Hatchery Outlet	0200410000	---		1500		1500
Hills Cr.	0200430000	ChS		1500		1500
Hills Creek Res.	0270200000	BuT, ChS			200000	200000
Junction City Pd. [1]	0276200000	---		14725		14725
Leaburg Lk.	0271700000	BuT, ChS	ad	28000		28000
McKenzie R-1	0201500000	BuT, ChS, OC	ad	35750		35750
McKenzie R-2	0201600000	BuT, ChS	ad	79500		79500
Quartzville Cr.	0201310000	---		12000		12000
Roaring R Park Pd.	0277700024	---		1080		1080
Salmon Cr.	0200410000	ChS		12000		12000
Salt Cr.	0200420000	ChS		3000		3000
Santiam R, N Fk.	0201100000	ChS		33000		33000
Smith Res.	0271000000	---		15000		15000
Timber Linn Lk.	0246900000	---		1725		1725
Trail Br Res.	0271100000	BuT, ChS	ad	14085		14085
Walling Pd. [1]	0261500000	---		5700		5700
Walter Wirth Lk. [1]	0255000000	---		24600		24600
Waverly Lk.	0246500000	---		910		910
Willamette R, Coast Fk.	0200200000	ChS, OC		2700		2700
Willamette R, Middle Fk.	0200300000	BuT, ChS	ad	6335		6335
TOTALS				688,685	500,000	1,188,685

[1] Some or all of the fish stocked in this waterbody come from Desert Springs Trout Farm instead of, or in addition to, an ODFW hatchery.

[2] BuT = bull trout, ChS = Willamette spring Chinook, OC =Oregon chub, StW = Willamette winter steelhead.

[3] Legal sized releases vary from 0.5 to 3 fish/pound.

[4] Fingerling sized releases vary from 30 to 100 fish/pound.

2.10.7.2 Hatchery Management Goals

The hatchery rainbow trout program is a segregated, or "isolated harvest" program, where the fish are produced for harvest and are not intended to spawn in the wild or be genetically integrated with any specific natural population.

2.10.8 Hatchery Mitigation Program Research, Monitoring & Evaluation

Proposed Action: **The Action Agencies, in coordination and collaboration with the Services and the WATER FPHM Committee, would develop and implement a RM&E program to determine compliance with, and effectiveness of, the hatchery-related actions described in Section 2.10. The RM&E program is intended to evaluate the effectiveness of the mitigation program in meeting legal mitigation requirements, supporting natural production of ESA-listed fish, and related effects on ESA listed fish species. The recommendations must be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.**

The Action Agencies envision a comprehensive Hatchery Mitigation RM&E Program. The framework includes a set of strategic planning questions and key RM&E program elements.

2.11 Habitat Restoration & Management Actions

This section describes measures ongoing and proposed by the Action Agencies to address management and restoration of habitat directly or indirectly used by ESA-listed species. The measures are broken down into the following categories:

- Habitat actions conducted onsite (on USACE-administered project lands).
- Habitat actions offsite (off of USACE-administered project lands) upstream and downstream of the basin dams and reservoirs.
- Measures to address habitat restoration associated with potential removal or modification of bank revetments and other forms of protection constructed and managed by the USACE under the Willamette Bank Protection Program.
- Ongoing and proposed research, monitoring and evaluation efforts by the Action Agencies related to aquatic habitat conditions.

2.11.1 Onsite Habitat Restoration & Resource Stewardship Actions

Proposed Action: **The USACE would continue to use existing authorities and programs for land and water resource stewardship on USACE-administered lands at the 13 Willamette projects to manage onsite habitat to benefit and protect ESA-listed species.**

Section 2.1 of the 2000 BA (USACE 2000) describes habitat management and natural resource stewardship actions undertaken by the Action Agencies on lands owned by the Federal Government and managed by the USACE and other entities at the 13 Willamette dams. In summary, within the Willamette Basin the USACE administers over 30,000 acres of project lands. In accordance with USACE regulations, those lands are managed for authorized project purposes within a system of land use allocation and classification. The USACE land use classifications define resource management and development practices, which may be either appropriate or inappropriate for that parcel of land. There are five land use categories into which lands at USACE projects may be classified: Project Operations, Recreation, Mitigation, Environmental Sensitive Areas, and Multiple Resource Management. The latter can be further subdivided into Low-density Recreation Use, General Wildlife Management, Vegetative Management, Inactive and/or Future Recreation Areas, and Easement Lands. The extent of these lands on each of the projects is summarized in Table 2-10 of the 2000 BA. There have been no changes in land use classification at any of the projects since the 2000 BA.

However, since 2000 the USACE has undertaken some changes in specific habitat management and resource stewardship practices that are directly or indirectly related to ESA-listed wildlife and plant species at a number of projects. These changes in management practices, which do not directly or indirectly affect ESA-listed fish species, are described in Section 3.5.1 of the Supplemental BA (USACE 2007a).

2.11.2 Offsite Habitat Restoration Actions

Proposed Action: **For offsite river reaches upstream and downstream of USACE project lands, the USACE would use its existing authorities under the General Investigations (GI) and Continuing Authorities Program (CAP) to undertake habitat restoration projects in the Willamette River Basin. Under these programs, the USACE has standing authorities to evaluate and implement aquatic ecosystem restoration projects throughout the basin. These programs do require cost-sharing and other forms of support from qualified non-Federal sponsors. They also are not currently a high budgetary priority of the administration, and Federal funds can be difficult to obtain. However, these programs are the only vehicle available to the USACE for undertaking habitat restoration off of USACE project lands.**

Section 1.6.1 of the 2000 BA (USACE 2000) includes a description of the GI and CAP programs, and included the projects underway at that time. The GI and CAP programs are the normal USACE mechanism for planning, designing, and constructing new projects and updating existing ones. Both programs include procedures for obtaining Congressional authorization and funding for project construction.

The habitat restoration projects in the Willamette Basin under development by the Action Agencies and their partners vary in size, design, scope, and location. In general, all habitat and bank protection-related restoration projects are intended to improve stream banks and adjacent river reaches by moving the trajectory of associated principle constituent elements of critical habitat within them toward a properly-functioning condition. Restoration projects are expected to improve hydrogeomorphic dynamics, large wood and sediment processes, floodplain forest recovery and connectivity, sediment transport processes, and channel complexity by replacing hardened (e.g., rip rap) bank structures that provide little geomorphic or biological benefit with more natural bank treatments containing large wood, riparian vegetation, and natural bank material. Additionally, some bank protection-related restoration projects may involve removal of a structure to reconnect off-channel habitat, providing additional rearing and holding habitat to improve abundance and productivity of UWR Chinook salmon and steelhead. Physical and biological monitoring is important in determining the effects of each project on geomorphic and biological processes within the project area. Results of the monitoring efforts would be important for designing and implementing future restoration projects, and for evaluating the response of listed species, their prey base, and habitat to the projects implemented.

2.11.2.1 General Investigations Program

The GI program is used by the USACE and non-Federal sponsors to generally address complex, large-scale, multiple purpose water resource projects that are specifically authorized by Congress. Projects under this authority can look at a broad and complex range of activities and have no authorized funding cap or limit. The GI study is conducted in two phases. The first phase, called the reconnaissance phase, is designed to identify water resource problems and opportunities in which there is a Federal interest in conducting a more detailed feasibility phase study. The feasibility study is conducted with 50/50 cost-sharing by a non-Federal sponsor. Feasibility studies are generally intended to lead toward recommendations for Federal water resource projects. The recommendations contained in feasibility studies are submitted forward for administration approval and Congressional authorization and approval. Implementation by the USACE requires both Congressional authorization and approval.

There are currently three ongoing feasibility studies in the Willamette Basin in which ecosystem restoration is a primary objective: (1) Willamette Floodplain Restoration Study; (2) Eugene/Springfield Metropolitan Area Watershed Study; and (3) Lower Willamette Ecosystem Restoration Study. Individually and collectively, these GI efforts have the potential to lead to future ecosystem restoration projects that could significantly benefit habitat requirements for ESA-listed aquatic and terrestrial species. However, none of these studies is expected to lead to project implementation prior to FY 2010.

Willamette River Floodplain Restoration Study

The 2000 BA (USACE 2000) described the Willamette River Floodplain Restoration Study, which was in the reconnaissance phase at the time. The feasibility study began in 2003 when the USACE executed a Feasibility Cost-sharing Agreement with the non-Federal Sponsor, the Willamette Partnership.

The purpose of the Willamette River Floodplain Restoration Study is to evaluate opportunities to modify existing floodplain features in the Willamette Valley to reduce flood damages while restoring natural wetlands and promoting ecosystem restoration.

After evaluating a number of alternative reaches of the Willamette mainstem and other subbasins, the Middle and Coast Forks were chosen as priority focus areas. These reaches were selected based on the potential for restoring floodplain and related habitat complexity and diversity, the availability of public lands on which to initiate restoration projects, and a high degree of interest by watershed councils and other local stakeholders. Efforts to date have focused on technical analysis of the study area reaches, including inventory and analysis of site conditions, development of baseline ecological and physical data, evaluation of historic and ongoing hydrogeomorphic conditions and processes, and preparation of hydraulic and ecological models. Preliminary analysis identified five reaches within the two rivers in the study area with high potential for ecosystem restoration. Depending on available funds, the USACE and non-Federal sponsor intend to continue with more detailed evaluation of the one or two highest priority reaches.

A key element of the study is evaluation of potential modifications of flow releases on the Coast and Middle Fork dams. This element of the study is being conducted by the USACE in partnership with The Nature Conservancy under the nationwide Sustainable Rivers Project (SRP). The Willamette SRP would build on the floodplain restoration study by developing environmental flow recommendations for the reaches downstream of the USACE dams and linking those flows to opportunities for stream channel and floodplain restoration, and improvement in operation of the dams. Given the existing floodplain restoration study, the initial SRP efforts is focusing on the Coast and Middle Forks and the mainstem Willamette River immediately downstream of these tributaries, as a pilot study that can be replicated in the rest of the Willamette system.

Possible outcomes and alternatives that might be recommended for implementation as a result of the Willamette Floodplain Restoration Feasibility Study include:

- Criteria and priorities for floodplain restoration activities.
- Conservation of floodplain lands.
- Removal and/or modification of bank revetments.
- Restoration of riparian corridors.
- Agricultural levee set-backs.
- Increased natural flood storage.
- Bio-sensitive channel bank and floodplain protection.
- Modification of reservoir operation.

The feasibility study is scheduled for completion in FY 2008. It is intended to be a pilot reach study; the tools, processes, and projects developed as a result of the Middle and Coast Fork studies would be exported to other reaches and subbasins in the Willamette Basin, although additional Federal and non-Federal funding would be required to expand the study beyond its current scope.

Eugene-Springfield Metropolitan Area Watershed Feasibility Study

The purpose of this study is to develop comprehensive water-resource improvement projects in four western watersheds within the urban metropolitan area – with benefits for multiple water resource objectives. These objectives include flood damage reduction, aquatic ecosystem restoration, water quality improvement, public use, waterway improvements and integrated watershed management. The study is initially focusing on two priority-planning corridors, Amazon and Cedar creeks. The USACE and non-Federal sponsors are currently developing cost estimates for conceptual alternatives along each creek. The study would eventually focus on practically all the waterways located in the metropolitan area of Eugene-Springfield, including the mainstem Willamette River and the McKenzie River.

Lower Willamette Ecosystem Restoration Feasibility Study

This study was initiated in FY 2004. The non-Federal sponsor is the City of Portland. The study would assess the feasibility of ecosystem restoration, including remediation of contaminated sediments over a portion of a 25-mile reach of the Willamette River in Portland. The feasibility study area encompasses the lower Willamette River watershed from Willamette Falls to its confluence with the Columbia River. The study objectives are to assess opportunities to: (1) increase the number of interconnected, active channels and open slack water areas; (2) increase shallow-sloped and less reinforced shoreline areas, and bank vegetation; (3) improve access to tributary streams; (4) increase emergent wetlands and riparian forest; and (5) improve sediment and water quality.

Under the current Federal funding environment, the feasibility study is scheduled for completion by FY 2011. In FY 2006, the USACE completed the without-project condition report, which identified numerous conceptual projects as shown in Table 2-29. This list is provided as an example of the types of restoration projects that may ultimately be implemented as a result of the feasibility study.

Table 2-29 Initial Screening of Potential Lower Willamette Ecosystem Restoration Projects

Project	Water Body	Potential Ecosystem Restoration Projects
Alsop-Brownwood	Johnson Creek	Create off-channel habitat for salmonids and water quality improvements. Create flood storage to mitigate nuisance flooding.
Arnold Creek Culvert	Tryon Creek	Retrofit Tryon Creek culvert to provide passage to lower Arnold Creek Bell Station. Create off-channel habitat. Purchase frequently flooded properties and create flood storage to mitigate nuisance flooding. Address exposed sewer pipe crossing creek.
Bell Station	Johnson Creek	Create off-channel habitat. Purchase frequently flooded properties and create flood storage to mitigate nuisance flooding. Address exposed sewer pipe crossing creek.
St. John's Landfill Boat Launch	Columbia Slough	Pull back banks and create wetland benches, create off-channel wetland habitat, and plant vegetation to create wildlife habitat.
BES Treatment Plant Banks	Columbia Slough	Lay back banks, increase amount and quality of vegetation, add anchored wood. Create small off-channel wetlands (if site uses and existing habitat can be protected).
Blind Slough	Columbia Slough	Valuable off-channel habitat with good existing riparian canopy and shrub vegetation. Habitat values can be increased by improving channel structure by adding large woody debris (LWD), increasing area of off-channel habitat, and minor revegetation.
Boones Ferry Culvert Retrofit	Tryon Creek	Retrofit culvert to provide passage from Tryon Creek State Natural Area to Marshall Park and Upper Tryon Creek.
Cathedral Park	Willamette Mainstem	Revegetate banks; retrofit parking lot and existing swale; create off-channel wetland habitat (includes increase in shallow water habitat), LWD placement.

Project	Water Body	Potential Ecosystem Restoration Projects
Centennial Mills	Willamette Mainstem	Demolition or redevelopment of this site provides the opportunity to improve banks and floodplain. Daylight Tanner Creek and create off-channel cool water confluence habitat.
City Banks opposite Kelley Point	Columbia Slough	Pull back banks and create small alcoves. Location at major confluence provides important connections to both Willamette and Columbia River fish populations.
Crystal Springs Culvert Replacements	Johnson Creek	Replace culverts at Tacoma and Tenino Streets and improve passage under private carport to improve access to restored habitat at Westmoreland Park.
Eastbank Crescent	Willamette Mainstem	Regrade and revegetate banks; increase shallow water habitat; incorporate stormwater treatment.
Elk Rock/Spring Park	Willamette Mainstem	Add wood, increase vegetation and enhance good existing habitat. Acquire property from willing sellers to increase complexity of off-channel habitat.
Freeway Land Company/East Lents	Johnson Creek	Create off-channel habitat for salmon and water quality improvement. Create flood storage to mitigate nuisance flooding. Purchase homes to move residents out of floodplain.
Kelley Point Park	Willamette Mainstem	Remove invasive plants and plant native species; create off-channel habitat
Kenton Cove	Columbia Slough	Add wood to enhance habitat complexity in this off-channel habitat.
Lower Powell Butte	Johnson Creek	Purchase frequently flooded properties from willing sellers. Restore floodplain and create off-channel habitat.
Marshall Park Channel Restoration	Tryon Creek	Improve channel conditions along Marshall Park by stabilizing banks with bio-engineering and adding instream complexity to improve habitat and water quality.
Middle TCSNA Habitat Enhancement	Tryon Creek	Enhance habitat by controlling erosion along the tributaries to protect mainstem habitat, replacing culverts, and increasing instream complexity along the mainstem.
Oaks Bottom Wildlife Refuge	Willamette Mainstem	Restore off-channel habitat; control invasive plant species; improve banks.
Oaks Crossing/Sellwood Riverfront Park	Willamette Mainstem	Improve amount and quality of vegetation in floodplain. Create off-channel and additional shallow water habitat that are consistent with park uses.
Oxbow at Errol Heights	Johnson Creek	Purchase frequent flooded properties and create flood storage to mitigate flooding. Rehabilitate wetlands. Create off-channel habitat.
Powers Marine Park	Willamette Mainstem	Remove invasive plant species, revegetate, establish wood jams, create off-channel habitat at the confluences of the seasonal streams flowing off the hillside.
Ramsey Refugia	Columbia Slough	Restore 5 acres of floodplain forest and backwater slough habitat by restoring hydrologic connectivity between Ramsey Lake Wetland and the Columbia Slough.
Smith and Bybee Lakes	Willamette Mainstem	Revegetate areas along the lakes. Upgrade water control structure to allow more natural hydrology and salmon access (in progress).
Stephens Creek Mouth	Willamette Mainstem	Maintain off-channel habitat; expand on existing high quality functions.

Project	Water Body	Potential Ecosystem Restoration Projects
Swan Island Beach South	Willamette Mainstem	Maintain habitat values at this site. Pull back banks, increase vegetation and wood, and restore floodplain.
Tryon Creek Confluence	Tryon Creek	Pull back steepened banks, improve composition of floodplain and frequency of inundation, vegetate banks, improve complexity of channel, add wood.
Tryon Highway 43 Culvert	Tryon Creek	Improve passage and channel conditions to improve access to one of the largest contiguous high quality habitats in the city, Tryon Creek State Natural Area.
Waterfront Park Bowl	Willamette Mainstem	Remove rip rap, plant native vegetation, create shallow water habitat, and increase bank complexity. Provide moorage to discourage anchoring on banks.
West Lents	Johnson Creek	Create off-channel habitat. Create flood storage to mitigate nuisance flooding. Purchase frequently flooded properties to move people out of the floodplain.
Westmoreland Park	Johnson Creek	Improve fish and wildlife habitat and fish passage in Crystal Springs and Westmoreland Park.
Willamette Cove	Willamette Mainstem	Restore consistent with site master plan. Create off-channel habitat. Remove riprap and regrade banks to expand shallow water habitat and floodplain. Increase vegetation on banks and floodplain.
Willamette Park	Willamette Mainstem	Improve over-steepened and hardened banks; revegetate, protect and enhance shallow water habitat; create off-channel habitat.
Wright and Moore Islands	Columbia Slough	Enhance good existing habitat by adding wood and looking for opportunities to excavate off-channel wetland habitat. Lay back banks at Heron Lakes to create wetland benches.

2.11.2.2 Continuing Authorities Program

The CAP generally includes smaller, single-purpose water resource projects for which Congress has delegated authority to the USACE to construct without specific authorization. Two of these authorities specifically allow ecosystem restoration projects, including restoration of habitat critical for recovery of ESA-listed species. Section 1135 authorizes the USACE to modify existing projects for ecosystem restoration, and the Section 206 authority is used to restore degraded aquatic ecosystems.

There have been no significant changes in these authorities from the descriptions contained in the 2000 BA (USACE 2000). They remain potentially valuable tools for the USACE and other Action Agencies to use to restore aquatic habitat conditions in the Willamette Basin. Provided below is an updated list of Willamette Basin projects currently in the Section 1135 and 206 programs.

Lower Amazon Creek Wetlands Section 1135

This project was constructed in partnership with City of Eugene. Construction was initiated in 1999 and substantially completed in 2004. The project removed approximately 24,000 linear feet of levee along Amazon Creek (a tributary to the Long Tom River) and restored floodplain connectivity between Amazon Creek and approximately 400 acres of wet prairie wetlands.

Eugene Delta Ponds Section 206

Construction was initiated in 2005 in partnership with City of Eugene. The project is providing floodplain and hydrologic connectivity to the Willamette River mainstem through a series of old gravel pits. After initial hydrologic connections were installed in 2006, juvenile salmonids were found using the restored rearing habitat almost immediately.

Springfield Millrace Section 206

The feasibility study is completed and design has been initiated. The project would protect, enhance, and create habitat for native wildlife and fish, including ESA-listed species by constructing a permanent water intake structure for the millrace; ensuring adequate water delivery to the millrace, millpond, and associated wetlands; placing fish screens to prevent fish entrapment; creating a main channel through the millpond and lowering the dam to increase water velocity through the pond; constructing a 20-acre wetland and swales in the millpond to increase wildlife habitat diversity and filter run-off into the millrace; and restoring riparian vegetation along the banks of the millpond. The project is currently on-hold due to lack of funding but would be resumed when funding becomes available.

Springwater Wetlands Complex Section 206

The feasibility study for this project is scheduled for completion in FY 2008. If implemented, the project would improve habitat for a wide variety of wildlife species, including neotropical migratory birds, waterfowl, shorebirds, amphibians, reptiles, and mammals. The ecosystem restoration project would include up to 40 acres of wetland and riparian restoration. Although the feasibility study itself is likely to be completed, implementation would be contingent upon Congressional approval and funding. NMFS therefore considers this a possible action.

Westmoreland Park Section 206

The feasibility study was completed in partnership with the City of Portland. The project would provide juvenile fish passage from Johnson Creek up to the upper end of Westmoreland Park; significantly improve aquatic habitat for ESA-listed salmonid rearing and refuge; provide a significant riparian corridor and wetland habitat for wildlife species; and significantly improve water quality conditions by eliminating the duck pond (which currently causes significant heating of the water), reducing excessive waterfowl use of the park, and reducing runoff of other contaminants by providing a buffer for the creek and wetlands. The project is currently on-hold due to lack of funding. The project would be resumed when funding becomes available.

Oaks Bottom 206

The feasibility study was completed in partnership with the City of Portland. The project would relocate culverts, restore lands north of the existing reservoir through excavation of channels, and restore critical habitat for ESA-listed salmonids. The project is part of the City of Portland’s “River Renaissance Project” that aims to restore the health of the Willamette River. Oaks Bottom is part of this larger initiative and is important to help restore native vegetation, improve water quality, and restore habitat for threatened and endangered fish species. The project is currently on-hold due to lack of funding, but would be resumed when funding becomes available.

2.11.3 North Santiam Gravel & Large Wood Restoration Study

Proposed Action: The Action Agencies, working in collaboration with the North Santiam Watershed Council and other project partners, would undertake a study to determine the potential for improvement of habitat conditions for ESA-listed species and other aquatic species through a well-planned gravel augmentation and large wood restoration project.

USACE met with technical representatives from NMFS, USFWS, ODFW, and the North Santiam Watershed Council in 2006 to discuss the potential for improving salmonid spawning through gravel augmentation and related habitat restoration activities, including large wood restoration. The team concluded that potential does exist but identified a number of research questions that should be addressed before a restoration project or projects can be designed. Research would consider gravel composition, gravel placement, hydrology effects on gravel transport, and estimates of habitat benefits.

The proposed study would be designed to address these questions. The objectives of the study are to: (1) define the problem; (2) identify potential solutions/alternatives; and (3) analyze costs, benefits, and environmental impacts of alternatives. The goal of the study is to identify gravel augmentation and/or large wood projects that can be carried out in the North Santiam basin to restore habitat. The Action Agencies assume that the North Santiam study results can also be applied to similar situations in other subbasins.

2.11.4 Willamette River Bank Protection Program

Proposed Action: The Action Agencies would possibly undertake a comprehensive evaluation of the habitat and biological impacts of revetments placed or funded by the USACE Willamette River Bank Protection Program. The objectives of the study would be to: (1) inventory and analyze the status of existing bank protection sites in the basin; (2) identify bank protection sites where removal or modification may be feasible to restore natural river functions; (3) evaluate the cumulative effects of bank protection on the river and riparian zone; (4) provide an estimate of areas threatened by future erosion and bank protection work; (5) reexamine procedures and criteria for justifying new bank protection projects; (6) identify and evaluate current and alternative bank protection measures; and (7) recommend and establish criteria for future bank protection works, including maintenance, repair and rehabilitation of existing sites. The study would be undertaken in close coordination with the Services.

Section 2.12 of the 2000 BA (USACE 2000) described the Willamette River Bank Protection Program. The USACE constructed about 100 miles of bank protection projects on the Willamette River and its tributaries. The USACE has not undertaken any new bank protection works nor repaired or replaced any of the existing project sites since the 2000 BA was completed.

A source of funding and a time frame for conducting the proposed study has not been identified. The USACE would place a priority on attempting to program funds and initiating the study as soon as possible.

The proposed study would include all USACE revetments in the Willamette Basin. There are approximately 330 revetments (those constructed by the USACE as well as by other entities) to be included in this review. The scope of the study would be developed in coordination with the Services. However, as a preliminary proposal the Action Agencies recommend the study encompass the following tasks:

1. Establish biological and physical goals and objectives.
2. Develop biological and physical criteria.
3. Perform complete inventory of bank protection sites.
4. Perform preliminary site evaluations.
5. Prepare conceptual designs and preliminary river hydraulics/channel-stability analysis.
6. Prepare final report.

2.11.4.1 Future Actions to Remove or Modify Revetments

Out of the 138 bank protection sites constructed by the USACE in the Willamette Basin, the USACE retains maintenance responsibility for only those 88 sites constructed prior to 1951; the remaining sites are maintained by a non-Federal sponsor. The USACE may be able to use operations and maintenance funding to modify sites for which the USACE does retain maintenance responsibility. However, those funds are likely to remain highly constrained.

It is more likely that the USACE would seek funds to implement the recommendations of the bank protection study through the GI and CAP Section 1135 and 206 authorities. In particular, the Willamette Floodplain Restoration Study is currently evaluating the potential for restoring floodplain restoration function on the reaches of the Coast and Middle Forks downstream of the USACE dams. The study would consider the potential for removing or modifying some of the approximately 30 bank revetments in the study area. As previously noted, non-Federal sponsorship would be required to implement project modification under CAP and GI authorities. Detailed design and hydraulic analysis necessary to undertake any bank revetment modifications would need to be done for any sites chosen for revetment modification or removal.

Despite the USACE's ongoing maintenance responsibility at some sites, the USACE is not authorized to remove or modify existing bank protection sites without first obtaining landowner approval and a non-federal sponsor. The sponsor must provide part of the funding for project construction and is responsible for maintaining the project when construction is complete. Before the USACE can remove or modify any of these projects, it must reach agreement with the project sponsor about the action. Even for those projects constructed prior to 1950 for which there is no local sponsor, the bank improvements are located on private lands, and thus landowner is required for any revetment removal or modification.

2.11.5 Habitat-Related Research Monitoring & Evaluation

Proposed Action: The Action Agencies would undertake certain habitat-related research, monitoring and evaluation measures in conjunction with the previously described existing authorities for land and water resource protection and management on USACE-administered lands, the CAP and GI programs, and the Willamette Bank Protection project. The RM&E program would be developed as part of the larger RM&E program described in Section 2.14, and would be coordinated through the RM&E Committee of WATER, described in Section 2.6.

Action Agency funding for RM&E activities is limited. The USACE has a national policy limiting expenditures for RM&E associated with ecosystem restoration projects to 1% of total project costs. The USACE would apply this policy to all restoration projects developed under the CAP and GI programs unless a waiver is granted by USACE headquarters. Likewise, funding available for RM&E in the USACE operations and maintenance budget is also constrained.

2.11.5.1 Aquatic Habitat Assessments

Proposed Action: By the end of FY 2007, the Action Agencies would complete ongoing surveys of aquatic habitat availability and condition in the Willamette River mainstem and major tributaries. The Action Agencies would distribute copies of the final report to the Services and would make the report and GIS format available on the internet.

The Action Agencies believe that accurate and current survey and assessment of aquatic habitat conditions in the Willamette River and tributaries would be necessary in order to compare and evaluate the entire range of ESA-related conservation measures under consideration by the Action Agencies in this revised proposed action as well as by others in the Willamette Basin.

In 2005, the USACE contracted with R2 Resource Consultants to prepare an inventory of all habitat surveys that had been completed to date. R2 Resource Consultants compiled a thorough list of all existing habitat surveys in the Willamette Basin, organized by river reach. The results of this inventory are described in the Willamette Valley Anadromous Fish and Bull Trout Habitat Assessment (R2 Resource Consultants 2005). Based on recommendations in the report, in 2006 and 2007 the USACE again contracted with R2 Resources to develop an appropriate protocol and complete a thorough habitat survey upstream and downstream of USACE dams. Approximately 157 miles of habitat were surveyed above the dams and 55 miles below dams in the North Santiam, South Santiam, Middle Fork, and McKenzie subbasins. As of April 2008, the subject report has not been completed.

2.12 STRUCTURAL MODIFICATIONS: FISH PASSAGE, TEMPERATURE CONTROL & HATCHERIES

This section deals with Action Agency proposed measures to address structural modifications at USACE dams in the Willamette River Basin that may be needed for improving the survival and productivity of ESA-listed species. The measures are broken down into the following categories:

- Modification of Willamette Temperature Control Project to add adult fish collection facilities at Cougar and defer construction of Blue River Temperature Control Facilities.
- Continued operation of the Cougar Water Temperature Control Facility.
- Evaluation of existing adult fish traps and potential modifications.
- Proposed strategy to comprehensively study project facilities and operations to improve survival and productivity of ESA-listed aquatic species.

2.12.1 Cougar Dam Adult Fish Collection Facility & RME Program

Proposed Action: **The Action Agencies would complete a Post-authorization Change (PAC) report for the Willamette River Temperature Control Project that would seek approval for modifying the authorized project to (1) add fish passage facilities at Cougar Dam; (2) undertake a detailed post-construction monitoring and evaluation program; and (3) defer construction of Blue River selective withdrawal capability. If approved, construction of the proposed fish passage facilities would be initiated in FY 2008.**

This section deals with recent and proposed structural modifications at Cougar Dam on the South Fork McKenzie River. This is the only location in the Willamette Project where significant structural modifications associated with ESA-listed species have occurred since the 2000 BA (USACE 2000) was completed.

At the time the 2000 BA was written, construction of selective withdrawal towers at Cougar and Blue River Dams was authorized under the Willamette River Temperature Control Project. The purpose of the project was to improve fish habitat conditions and increase productivity in the mainstem McKenzie River, South Fork McKenzie River, and Blue River by restoring a more normative temperature regime below the dams. Construction of the selective withdrawal tower at Cougar Dam was completed in December 2004. Although the Blue River Dam tower was anticipated to begin in 2002, construction has not been initiated. This was partially the result of cost overruns in the construction of the Cougar selective withdrawal tower. However, the USACE, state, and Federal resource agencies agreed that providing fish passage at Cougar Dam may be a more cost-effective means for increasing productivity for spring Chinook than the inclusion of temperature control at Blue River. The USACE prepared a PAC report to evaluate and recommend alternatives including constructing fish passage facilities at Cougar Dam in lieu of selective withdrawal at Blue River.

Construction of the Cougar Dam WTC facility was covered under a separate Biological Opinion (NMFS and USFWS 2000). However, continued operation of the facility as an integral part of Cougar Dam and the Willamette System is addressed under this Section 7 consultation for the Willamette Project. A separate Biological Opinion has been prepared addressing construction of the proposed fish passage facilities at Cougar Dam (NMFS 2007a).

In the PAC, the USACE proposes to construct a permanent fish trap-and-haul facility to restore connectivity between fish populations located above and below the Cougar project. Additionally, the USACE proposes to fund an extended biological monitoring and evaluation program of the downstream ecosystem and of fish entrainment in the tower to determine and insure the most effective protocol for implementation of water temperature control and of the trap-and-haul program, and to document the biological benefits realized from these protective and restorative measures. The USACE proposes to reduce the operating hatchery mitigation program when the monitoring and evaluation program and other studies demonstrate successful natural production of juveniles and of adult return rates leading to a self-sustaining population of Chinook salmon above Cougar Dam. Finally, the USACE proposes to defer construction of the Blue River WTC structure indefinitely.

2.12.2 Willamette Valley Fish Handling & Transport Facilities Improvements

Proposed Action: The Action Agencies would evaluate Willamette Valley fish handling and transport facilities associated with the dams and possibly carry out modifications determined to be necessary to meet requirements for ESA-listed species as soon as programmed funds can be made available.

Subsequent to completion of the 2000 BA, the USACE undertook initial efforts to evaluate facility needs for listed fish species at collection facilities at Willamette dams and selected hatchery facilities. The South Willamette Valley Fish Facilities Improvements Conceptual Design Report (McMillen Engineering 2005) reviewed existing fish trapping facilities at Minto Pond on the North Santiam River, Foster Dam on the South Santiam River, Dexter Pond on the Middle Fork Willamette, and Fall Creek Dam on Fall Creek. This report evaluated the existing condition of each fish facility and determined that the existing trapping facilities do not have adequate collection, sorting, holding, and transport capabilities to handle ESA-listed fish or meet the demands of current hatchery operations. The report also presented conceptual design alternatives for improving the existing facilities to (1) meet updated criteria for reducing stress, injury, and mortality of ESA-listed species, including hatchery fish; and (2) to allow safe and efficient sorting of hatchery and wild fish, as necessary for current hatchery operations. Table 2-30 summarizes the recommended improvements for each of the fish handling facilities, as well as preliminary cost estimates. The Action Agencies would seek input from the Services regarding the most appropriate design features for each facility and hope to incorporate common design elements into each facility to facilitate ease of operation, maintenance, and repair.

Table 2-30 Recommended Improvements to Fish Handling Facilities as Described in the Conceptual Design Report.

Facility	Existing System Modifications*	New Facility Components*	Estimated Project Cost
Minto Pond	Raise barrier dam crest with Obermeyer spillway gate. Upgrade existing access road.	Intake with fish screen. Fish ladder Pre-sort holding ponds. Elevated sorting facility including sorting area, post-sort raceways, crowding channel, & truck loading. Complete electrical system.	$10,003,000
Foster Dam Trap	Tie to existing fish ladder entrance and AWS.	Fish ladder. Pre-sort holding pond. Elevated sorting facility including sorting area, post-sort raceways, crowding channel, & truck loading. Broodstock holding and spawning facility.	$7,546,000
Dexter Pond	Install intake screen on existing intake. Install new fish entrance barrier panel. Install new floor diffusers for existing pre-sort holding pond. Install new fish crowder on existing pre-sort holding pond. Upgrade electrical system/controls.	Fish lock. Elevated sorting facility including sorting area, post-sort raceways, crowding channel, & truck loading.	$5,748,000
Fall Creek Dam Trap	Inspect and repair/replace existing gates and pumps. Replace electrical system and control panels. Install gravity water supply pipe from fish horns to elevated sorting facility.	Fish lock. Elevated sorting facility including sorting area, post-sort raceways, crowding channel, &truck loading.	$3,751,000

* These proposed modifications and new design features are recommended by the Conceptual Design Report and describe the types of modifications (or reconstruction) necessary at each facility. However, the USACE would work with the Services as it develops more detailed designs, which may include changes to some of these features. Source: McMillen Engineering 2005.

The Action Agencies consider upgrading these facilities a high priority. The USACE is seeking funding through the operations and maintenance budget's Critical Infrastructure Program. The USACE believes that the highest priority among the four sites evaluated is the Minto Pond Fish Collection Facility below Big Cliff Dam on the North Santiam River.

The President's FY 2008 budget includes $200,000 for developing a Detailed Design Report from the Minto Trap initial conceptual design. The Action Agencies would continue to seek program funds for completion of design and construction of the Minto Pond facility in the out years. The Action Agencies would work with the Services and other resource agencies to establish priorities among the other fish handling facilities. Evaluation of those alternatives would be integrated into the system review studies described in Section 2.12.3.

Proposed Action: The Action Agencies would develop post-construction maintenance, monitoring, and evaluation plans for the each of the four fish collection and handling sites listed in Table 2-30 (above), starting with the Minto Fish Collection Facility. The plans would include the following elements:

Post-construction Hydraulic Evaluation Plan & Report

The Action Agencies would develop a plan to document that the collection and transport features of the facility were constructed and operate as designed and intended. Verify that hydraulic conditions (e.g., water velocities, barrier heights) are consistent with the design criteria developed collaboratively with the Services and with WATER. If deficiencies are identified, develop and implement solutions in collaboration with the Services and WATER. Prepare a post-construction hydraulic evaluation project report that summarizes the results.

Post-construction Biological Evaluation Plan & Report

The Action Agencies would develop a plan to verify the effectiveness of fish collection, guidance, and/or exclusion devices (i.e., ensure the facility is collecting/guiding fish with minimal delay and injury and identify injury and mortality associated with each component of the facility and with associated release procedures, if applicable). If deficiencies are identified, the Action Agencies would develop and implement solutions in collaboration with the Services and WATER. The Action Agencies would prepare a post-construction biological evaluation project report that summarizes the results.

Maintenance Plan & Annual Maintenance Reports

The Action Agencies would develop a protocol for regularly inspecting all fish passage facilities to ensure continual operation with minimal potential for injury and mortality throughout the duration of the fish passage season. The plan would include a procedure for reporting, addressing, and correcting any deficiencies including seeking input from WATER and the Services regarding possible solutions. The plan would allow for the Action Agencies to correct any deficiencies identified to a properly functioning condition within a reasonable period of time after deficiencies are identified, consistent with the scope and nature of the deficiency and the availability of funds needed for correcting the deficiency. Provide an annual maintenance report summarizing the results of monitoring and maintenance activities. It would include identification of any deficiencies noted or solutions implemented to correct them.

Development and Implementation of an Operational Protocol & a Monitoring and Evaluation Plan & Annual Monitoring Reports

The Action Agencies, in collaboration with WATER, would develop an operational protocol for the fish trapping and handling facilities and a plan for monitoring all operations associated with the facilities, including the number of each species passing through the facility, species-specific injury and mortality rates, any modifications or special operations of the fish passage facilities, any unusual problems or events related to the facilities and local fish populations handled, and plans to correct any problems that are identified. The Action Agencies would prepare an annual monitoring report that summarizes the above information.

2.12.3 Willamette System Review Study

Proposed Action: The Action Agencies would undertake a series of studies looking first comprehensively at the entire basin and then systematically at the key subbasins to evaluate the feasibility and relative benefits of structural and related operational modifications to the Willamette dams designed to improve survival and productivity of ESA-listed aquatic species. Collectively called the Willamette System Review Study, these studies would include evaluation of (1) the technical feasibility; (2) biological justification; and (3) cost-effectiveness of these and other potential proposed measures so that the relative effectiveness and efficiency of potential Federal actions can be compared. In addition to addressing the ESA issue, the System Review Study would also address structural and operational needs associated with CWA compliance. The studies would be conducted in close coordination with the Services and other appropriate state and Federal resource agencies and tribes. The studies would result in decision documents stating agency positions on individual measures. For those measures determined to be feasible and recommended, the Action Agencies would seek authorization and appropriation for implementation through normal budget and program procedures.

The following potential structural modifications would be evaluated as part of the System Review Study:

- Improving existing adult fish collection and handling facilities at Dexter Dam, Fall Creek Dam, Foster Dam, and Minto Fish Collection Facility below Big Cliff Dam (see Section 2.12.2).
- Upgrading and updating adult and juvenile fish passage facilities at those projects where passage was authorized and constructed as part of the original project, including Foster, Green Peter, Cougar and Fall Creek Dams.
- Evaluating the potential for providing adult and juvenile fish passage at those dams in the basin where passage facilities were not constructed as part of the original project, including Big Cliff, Detroit, Blue River, Lookout Point, Hills Creek, Dorena, Cottage Grove and Fern Ridge Dams (including adult volitional passage as a potential long-term alternative solution).
- Modifying and/or replacing existing fish hatchery facilities constructed to mitigate for the impacts of the projects (see Section 2.10).
- Providing selective withdrawal capacity or other alternative methods to achieve more normative downstream water temperature regimes.

The Action Agencies state in the Supplemental BA (USACE 2007a):

> "decisions to implement the proposed structural modifications should be based on an agreed upon set of criteria that include a full lifecycle analysis of the listed species that would take into account the comprehensive beneficial

> effect of proposed Federal mitigation actions, in the context of all the environmental factors affecting the survival and fitness of the species."

In most cases, the USACE and Reclamation do not have existing authority and/or the funding necessary to implement them. The Action Agencies are required to work through the necessary Federal planning, program and budget process to evaluate project modifications and seek necessary authorization and funding.

Figure 2-13 (below) presents a conceptual diagram of the proposed steps or phases in the Willamette System Review Study process. The Action Agencies envision the study being conducted in phases:

Phase I: Reconnaissance Study

Phase II: Systemwide Feasibility Phase Study

Phase III: Subbasin System Configuration Studies

Phase IV: Detailed Preconstruction Engineering and Design

Phase V: Implementation.

Plate 1 (located at the end of the Supplemental BA) presents a conceptual schedule for the system configuration studies. The intent is to show a possible logical progression of efforts based on the assumption that resources to undertake the studies would be limited. Completion of the studies and ultimate implementation of recommended projects is dependent on the Action Agency's receipt of adequate funds and necessary authorization. If funds are available, it would be possible to expedite the schedule by conducting more overlapping phases.

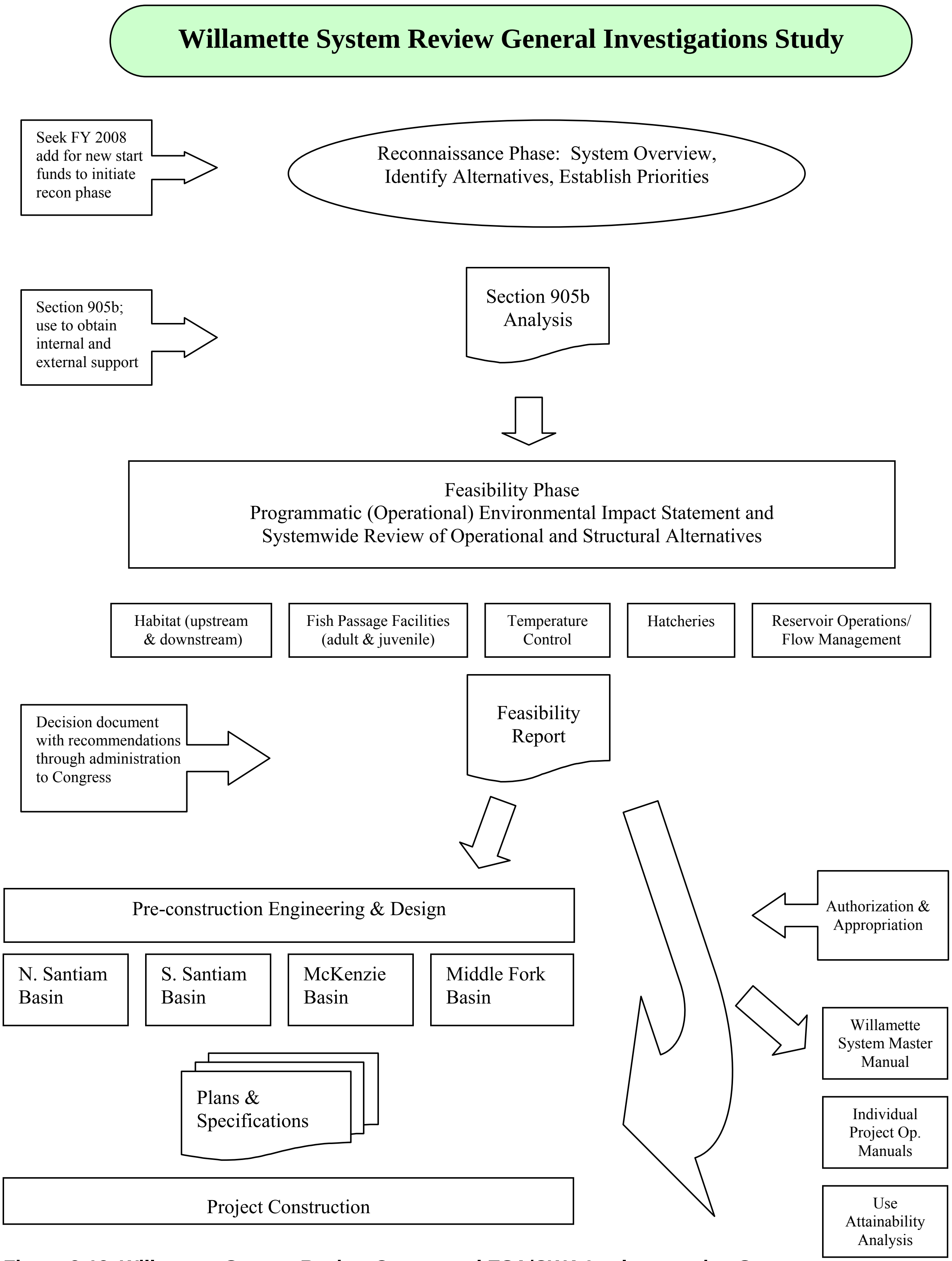

Figure 2-13 Willamette System Review Conceptual ESA/CWA Implementation Strategy.

The major steps and phases of the proposed Willamette System Review Study are described below.

2.12.3.1 Phase I: Reconnaissance Phase Study

The initial phase of the Willamette System Review would be a reconnaissance phase study. The reconnaissance study would be used primarily to establish a basis for moving forward into more detailed feasibility studies in Phase II. The reconnaissance study would:

- Include a regional (basin-wide) overview of structural problems and opportunities related to ESA and CWA compliance that would set the stage for the more detailed subbasin studies that would follow;
- Identify and describe the full range of potential structural and related operational measures and alternatives that would be evaluated in the more detailed feasibility studies to follow;
- Address integration of potential Action Agency measures with ongoing NMFS and ODFW Recovery Planning efforts for ESA-listed salmonids in the Upper Willamette ESU;
- Provide initial definition of detailed evaluation criteria to be used for determining technical feasibility, biological merit, and cost-effectiveness of the measures to be evaluated. Criteria developed in Phase I would be applied to the detailed studies conducted in Phase II;
- Establish initial priorities for evaluating structural and operational alternatives and for the order in which subbasins would be evaluated; and,
- Provide the basis to scope the more detailed feasibility phase studies to follow.

The reconnaissance report completed at the end of this phase would be used to communicate the scope and purpose of the feasibility studies and to seek support and consensus from stakeholders (including the State of Oregon, other Federal and state agencies, tribes, and others) regarding the proposed approach. The Action Agencies would seek funding to initiate the reconnaissance study during FY 2008. It is expected to take approximately 1 year to complete.

2.12.3.2 Phase II: Comprehensive Systemwide Feasibility Study

Phase II of the Willamette System Review Study would be a systemwide feasibility study. The final feasibility report would be a decision document that would make recommendations through review and approval chains within the Action Agencies, and where necessary the administration and Congress, in regard to measures thought to be justified. Where shown to be justified, the Action Agencies would seek the necessary authorization and appropriation for implementation. The feasibility report would include the necessary National Environmental Policy Act (NEPA) documentation for implementation of proposed actions. Public involvement and outreach would need to be part of the feasibility study process. The systemwide feasibility report may also provide the foundation for the USACE to move forward on updating individual project operating manuals and possibly developing an operations master manual.

The systemwide feasibility study would include a preliminary evaluation of structural alternatives, including:

- Fish handling and passage facilities (such as ladders, screens, juvenile bypass systems, spillway modifications, stilling basin improvements, etc).
- Temperature control facilities (selective withdrawal towers and other alternatives).
- Hatcheries
- Modification of revetments bank protection sites.

The feasibility study is not intended to be an evaluation of a full range of operational alternatives. However, it would include a preliminary study of operational alternatives to the extent that they are related to structural alternatives, such as:

- Operational changes that should be considered as alternatives to structural modifications; or
- Operational changes that may be needed to fully realize the benefits associated with structural modifications.

The Action Agencies expect to begin the Phase II study no earlier than FY 2009 and complete it within approximately 30 months.

2.12.3.3 Phase III: Subbasin Detailed System Configuration Study

Phase III would consist of a series of detailed feasibility level system configuration studies conducted for each of the major subbasins in the Willamette Basin on which USACE projects are located. The order in which the subbasin studies would be conducted would be based on priorities determined in Phases I and II and may be reordered as more knowledge of problems and solutions is obtained. The Action Agencies would initiate the first Phase III study (North Santiam) concurrently with Phase II and complete them simultaneously so that the Phase II decision document can be submitted forward for necessary authorization or approval of specific measures for implementation in the highest priority subbasin as expeditiously as possible.

The Phase III studies would include detailed evaluation of potential structural and operational alternatives at individual USACE dams in the Willamette Basin within their respective subbasins. The primary objective of the Phase III studies would be to recommend for implementation those measures shown to be technically feasible, biologically justified, and cost-effective. Adequate NEPA compliance and documentation would be included in the scope of each of the subbasin studies to ensure that recommended measures may be implemented.

Phase III studies would include the following:

- Technical Feasibility: the Action Agencies would plan, design and engineer the alternatives to a sufficient level of detail (10% to 30% design, depending upon the complexity and uniqueness of the facility) to make a determination of technical feasibility and to estimate costs of alternative measures.
- Biological Justification: the Action Agencies would carry out a detailed evaluation of the environmental baseline of habitat conditions and potential future condition of habitat upstream and downstream of Willamette dams. This would allow a comparison of current

and expected future environmental conditions both with and without the proposed alternative measures. Additionally, the Action Agencies would develop, test, calibrate, and use widely accepted biological life-cycle models (e.g., the COMPASS model used for supporting decisions on the Columbia River) or other tools to estimate and forecast survival and productivity of listed species under baseline conditions and under various alternative measures and strategies. Decisions regarding which model or models to use and the metrics they measure would be developed in coordination with NMFS, USFWS, and other stakeholders, and agreed upon within the region through the conduct of the feasibility study. Input parameters for any population models developed and used for this purpose would need to be based on collected site- or reach-specific field data. In order to achieve these objectives, the Action Agencies propose substantial biological RM&E in conjunction with the Phase III (and Phase II) studies. Section 2.12.3.6 describes a framework of RM&E proposed by the Action Agencies in conjunction with the system review studies.

- Cost-effectiveness: the Action Agencies would undertake a cost effectiveness/incremental cost analysis (CE/ICA) process to evaluate projects where the primary outputs are ecological rather than monetary. To accomplish this analysis, the Action Agencies would need to produce quantifiable estimates of ecological outputs as well as accurate estimates of costs to construct, operate, and maintain the proposed measures, as well as other related costs such as benefits foregone to other authorized project purposes (flood control, hydropower, irrigation, recreation, etc) as a result of implementation.

2.12.3.4 Phase IV: Pre-construction Engineering & Design Study

Phase IV consists of detailed pre-construction engineering and design necessary to award contracts and construct structural measures recommended for implementation. The scope and schedule of pre-construction engineering and design would depend on the type and extent of measures proposed for implementation following Phase III.

2.12.3.5 Phase V: Implementation

The Action Agencies would implement structural and operational measures following project approval by Action Agency higher authority and Congressional authorization and appropriation where necessary.

2.12.3.6 Research, Monitoring & Evaluation Program for the Willamette System Review Study

The Action Agencies note that substantial biological RM&E would need to be conducted in conjunction with the proposed Phase I, II, and III studies. The RM&E would provide the basis for comparing and evaluating alternatives and for demonstrating effectiveness (performance measures) and to determine the feasibility of implementing fish passage, temperature control, and other related measures. In the Supplemental BA (USACE 2007a), the Action Agencies list numerous questions regarding fish passage and water temperature control that should be addressed by the RM&E program. The recommendations for a RM&E Program would be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

2.12.4 Construction Projects Environmental Coordination & Management

Proposed Action: Working through the Technical Coordinating Committee of WATER described in Section 2.6, the Action Agencies would collaborate with the Services on the design, construction, and operation of all potential structural modifications to the dams and associated facilities, including fish collection and handling facilities, fish passage improvements, and water temperature control facilities designed to improve conditions for ESA-listed species.

In the Supplemental BA (USACE 2007a), the Action Agencies recognize that there is a high degree of uncertainty regarding the types, locations, and extent of structural modifications that may ultimately be implemented through the System Review Study (Section 2.12.3). In order to reduce the uncertainties surrounding these potential modifications, the Action Agencies propose to collaborate with the Services on planning, designing, and constructing the potential facilities.

As proposed in Section 2.6, one of the proposed committees of WATER is the CPEC Committee. The CPEC Committee would be a standing committee established to assist in review of all future construction projects in the Willamette Basin related to ESA recovery actions including improvements for fish passage, collection and handling, hatcheries, and WTC facilities. Responsibilities of the CPEC Committee are described in detail in the Supplemental BA (USACE 2007a), and include the following: facility planning and design, developing standard operating plans and procedures, effects assessment, and reviewing biological monitoring and evaluation plans.

Proposed Action: The Action Agencies would adopt and follow best management practices (BMPs) for construction of all potential structural modifications to the dams and associated facilities including fish collection and handling facilities, fish passage improvements, and water temperature control facilities designed to improve conditions for ESA-listed species.

The CPEC Committee would assist the Action Agencies in development of construction BMPs. At a minimum, the Action Agencies would adopt the basic BMPs outlined in the Biological Opinion for the Cougar Dam Fish Collection Facility (NMFS 2007a) to avoid or minimize unavoidable effects on ESA-listed species or critical habitat. These may consider but are not limited to:

- Timing of in-water work periods.
- Confinement of construction work areas.
- Preconstruction activities: marking and flagging to minimize impacts to prevent ground disturbance to critical riparian vegetation, wetlands, and other sensitive habitat.
- Cessation of work causes and protocols.
- Use of fish screen and other protective devices.

- Pollution and Erosion Control Plans: erosion controls such as temporary in-place controls, emergency controls and materials, and inspection; construction discharge water control such as water quality collection and treatment, discharge velocity, pollutants, and drilling discharge; and stormwater management plan.
- Restrictions on heavy equipment use.
- Vehicle and materials staging and inspection.
- Conservation of native materials and site restoration.
- Minimization of earthwork impacts: drilling, sampling and site stabilization
- Treated wood: piling installation and removal.

2.12.5 Conceptual Implementation Schedule

Proposed Action: The Action Agencies would, within 5 years of completion of the final Biological Opinion for the Willamette Project, do the following:

- Complete a PAC Report on the Willamette Temperature Control Project; assuming that the draft recommendations in PAL are approved, construct and initiate operation of fish passage facilities at Cougar Dam; and, undertake a detailed monitoring and evaluation program of the operational selective withdrawal tower and fish passage facilities.
- Possibly construct upgraded fish collection, handling, and transport facilities at the Minto location on the North Santiam River and completed detailed design analysis on other high priority sites.
- Completed Phase II of the Willamette System Review Study, including processing the initial Phase III decision document through the Action Agency review and approval process, establishing Action Agency position and recommendations regarding implementation of other potential structural modifications such as fish passage and temperature control at the highest priority locations in the basin.

2.13 WATER QUALITY ACTIONS

This section describes Action Agency existing and proposed measures for improving water quality conditions associated with operating the USACE Willamette projects including:

- An update on operation, monitoring and evaluation of the Cougar Dam WTC tower (proposed actions for evaluating the potential for implementing additional WTC facilities at other dams in the basin are described in Section 2.12).
- Measures to address the TMDL for temperature and other water quality parameters in the basin.
- Existing and proposed water quality research, monitoring and evaluation.

2.13.1 Cougar Dam Temperature Control Project

Proposed Action: In coordination with the WATER Flow Management and Water Quality/Temperature committees, the USACE would continue to operate the Cougar Water Temperature Control project to meet downstream water temperature targets required for protection of Chinook salmon and other aquatic species.

2.13.1.1 Continued Operation of the Cougar WTC Facility

The 2000 BA (USACE 2000) described the planned construction of the selective WTC tower at Cougar Dam. Construction was initiated in 2000, completed in December 2004, and was fully operational by May 2005. Operation for temperature control requires selectively withdrawing water from different elevations in the pool to meet target outflow temperatures. Operational decisions on the flow distribution are based on the outflow and data from temperature instrumentation on the face of the structure. Gates can be "throttled" at different levels to control the proportion of flow from different levels. During construction of the WTC, the electrical generation system at Cougar Dam was upgraded to include replacement of turbine runners with "fish friendlier" runners that utilize minimum gap technology.

The Cougar WTC tower would continue to be operated as an integral element of the Willamette system of reservoirs. The Action Agencies would operate the Cougar WTC and the other elements of the system in close coordination with the FM Committee of WATER, as described in Section 2.6. Because of Cougar Dam's status as the only dam in the Willamette system with WTC capability, USACE operations would be coordinated with the WQTC Committee of WATER.

2.13.1.2 Cougar Dam WTC Research, Monitoring & Evaluation

Section 2.12.1 describes the Action Agencies' proposed action to complete a PAC report for the Willamette River Temperature Control Project that would seek approval for modifying the authorized project to: (1) add fish passage facilities at Cougar Dam; (2) defer construction of the Blue River selective withdrawal capability; and, (3) undertake a detailed post-construction monitoring and evaluation program. The current post-construction biological monitoring and evaluation program for the Cougar WTC is very limited and is expected to end with conclusion of construction. As part of this proposed action, the Action Agencies would carry out an extensive RM&E program to evaluate the biological effectiveness of the Cougar WTC, as well as fish passage at Cougar Dam.

2.13.2 TMDL Water Quality Management Plan

Proposed Action: The Action Agencies would coordinate with ODEQ, USEPA, USFWS, and NMFS to prepare a WQMP for the Willamette Project that would address the Willamette TMDL for temperature and other water quality parameters consistent with the needs of ESA-listed aquatic species. The Willamette WQMP should be completed no later than March 2008.

2.13.2.1 Background

In September 2006, ODEQ released and USEPA approved a final TMDL for the Willamette Basin that was developed by ODEQ under the requirements of the CWA. A TMDL is a pollution analysis conducted with the primary purpose of determining how much a pollutant must be reduced in order to meet state water quality criteria. Temperature and TDG are the two pollutants or particular relevance to the USACE dams and the life cycle requirements of ESA-listed aquatic species. The Willamette TMDL established temperature load allocations in the form of target temperatures for each USACE dam in the Willamette Basin. The load allocations were based on estimates of "natural thermal potential" (NTP) of the individual streams under a "without dam" condition.

The USACE expressed concern with the temperature load allocations placed on USACE dams, because even if selective withdrawal facilities were constructed, the USACE dams would not be able to meet the TMDL targets (USACE 2007a). The USACE also noted that even at Cougar Dam, where WTC facilities have been installed, actual flow releases cannot meet TMDL targets, although releases are generally meeting the biologically-driven temperature targets established in conjunction with NMFS, USFWS, and ODFW.

While ODEQ did not adjust the final estimates of NTP or temperature load allocations in response to USACE concerns, ODEQ indicated a willingness to work with the USACE and others to further refine load allocations and NTP and possibly undertake a Use Attainability Analysis that could result in modified targets.

The final TMDL identified the USACE dams as "non-point sources" for temperature. The USACE is identified as a Designated Management Agency for temperature, and as such the ODEQ expects the USACE to prepare a TMDL WQMP. The Action Agencies stated in the Supplemental BA (USACE 2007a) that despite legal and policy uncertainties regarding the role of the Clean Water Act with respect to Federally-owned and operated facilities, the USACE had agreed to coordinate with ODEQ on development of a WQMP to address the Willamette TMDL.

2.13.2.2 Water Quality Management Plan

Proposed Action: The Action Agencies would coordinate with ODEQ, USEPA, and the Services to prepare a WQMP for the Willamette Project that would address the Willamette TMDL for temperature and other water quality parameters consistent with the needs of aquatic species listed under ESA.

The WQMP would address the following five major topics.

1. Participate in an Interagency Management Process for temperature-related improvements in the Willamette Basin. The Action Agencies propose that the WATER regional forum described in Section 2.6, specifically the WQTC Committee, would be the interagency forum for integration of temperature and other water quality-related improvements associated with the Willamette Project.

2. Assist with collection and analysis of data necessary to support ODEQ revisions of load allocations for each of the 13 dams and reservoirs. Section 2.13.3 describes ongoing and potential water quality-related RM&E activities associated with operation and maintenance of the Willamette Project. Additionally, the Action Agencies propose an extensive RM&E program associated with the Cougar WTC, as described in Section 2.13.1.2. This evaluation of the effectiveness of the Cougar WTC would inform decisions for addressing temperatures and related ESA needs at other Willamette project dams.
3. Demonstrate compliance and consistency with the Biological Opinion for the Willamette Project. The Action Agencies would work with the members of the WQTC Committee, including the Services, to ensure that the WQMP is consistent with and complies with the requirements of this ESA Section 7 consultation.
4. Develop a temperature management plan that would show temperature improvements needed to achieve load allocations. The Action Agencies propose to analyze and address temperature issues at Project dams through the System Review Study described in Section 2.12. Additionally, the Action Agencies propose to work with ODEQ, NMFS, and USFWS to demonstrate that they are doing everything possible to manage for temperatures within the existing structural limitations of the projects. This may include performing additional modeling of operational alternatives.
5. Develop a data and information strategy that may be used for future use attainability analyses for the dams. The Use Attainability Analysis is a process authorized under the CWA for changing a state-approved water quality standard if it can be shown that the standard cannot be attained. The Action Agencies indicate in the Supplemental BA (USACE 2007a) that the Use Attainability Analysis may be the appropriate action in the case of many of the Willamette Basin dams and propose to coordinate with ODEQ to determine when and where a Use Attainability Analysis process should be applied.

2.13.3 Water Quality Research Monitoring & Evaluation

2.13.3.1 Ongoing Willamette Water Quality Monitoring Programs

Proposed Action: The Action Agencies will continue to collect and analyze water quality data at Project dams, including upstream and downstream of dams and in the reservoirs.

In the Supplemental BA (USACE 2007a), the Action Agencies note that official USACE policy requires water quality monitoring at Federal projects. Although water temperature data was historically collected at USGS gage stations upstream and downstream of nearly all of the USACE Willamette dams, budget cuts over the years resulted in some sites being dropped. However, because of TMDL and ESA issues, the USACE recently restored funding for water temperature and TDG data collection at inflow and outflow sites. Also, the USACE is now collecting in-lake water temperature profiles from surface to bottom at Willamette projects that need water quality temperature models.

Proposed Action: If funding is available, the Action Agencies will continue to conduct site-specific water quality studies when new water quality issues arise at a project.

Recent examples of site-specific water quality studies include harmful algae blooms at Hills Creek Reservoir and mercury loading from an abandoned mine at Cottage Grove reservoir. When this happens the USACE conducts studies (funding permitting) to evaluate the problem. For instance, phytoplankton and water samples were collected at Hills Creek Reservoir to identify potentially toxic blue-green algae and to determine the concentrations of toxic chemicals produced by the algae. Mercury studies were conducted at Cottage Grove and Dorena Reservoirs to characterize mercury dynamics in these reservoirs.

Proposed Action: The USACE proposes as a goal to develop temperature models for all of the Willamette projects so that project operations and improvements can be evaluated in relation to TMDL and ESA requirements.

The USACE has recently begun collecting inflow, in-lake, and outflow temperatures at the projects to populate temperature models, particularly those that do not have temperature models in place. Temperature models have been developed for the large storage projects – Hills Creek, Lookout Point/Dexter, Cougar, Blue River, Green Peter/Foster, and Detroit. The smaller, lower elevation projects – Cottage Grove, Dorena, Fall Creek, and Fern Ridge – need temperature models developed. These models may also be useful in determining whether to modify TMDLs, in developing the Willamette WQMP and Use Attainability Analysis.

Proposed Action: The USACE proposes to complete a Water Quality Program Management Plan to guide future water quality staffing, monitoring, and evaluation activities and to provide managers with estimates of funding requirements.

This program planning activity would be conducted by the Portland District's Reservoir Regulation and Water Quality Section. The need to meet USACE water quality monitoring policy and the impact of TMDL and ESA issues would play an important role in shaping the Water Quality Program Management Plan.

2.13.3.2 Potential Framework for Water Quality RM&E

Proposed Action: The Action Agencies would work with the WQTC Committee to develop and carry out a comprehensive water quality/temperature RM&E program. The recommendations for a water quality RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee (see Section 2.14) and follow the principles and strategic questions developed by the committee.

As described in the Supplemental BA (USACE 2007a), the RM&E program would address the respective needs for CWA compliance under the temperature TMDL and life cycle requirements for ESA-listed aquatic species. It would integrate the existing and ongoing RM&E activities conducted by ODEQ and others in development of the temperature TMDL with ongoing water quality monitoring and evaluation by the USACE and others. It would need to be a central element of the proposed system configuration studies evaluating the feasibility of temperature control and other potential structural and operational alternatives described in Section 2.12.

The Action Agencies do not currently have a clearly established source of funding available for a comprehensive water quality monitoring and evaluation program in the Willamette Basin. Funding for the water quality/temperature RM&E program would need to be derived from a variety of sources, including ongoing operations and maintenance funding, Cougar Dam/Willamette Temperature Control Project and from funding for the system configuration studies. The earliest that significant funding may be available for this program is FY 2009.

2.14. RESEARCH, MONITORING & EVALUATION PROGRAM

Proposed Action: The Action Agencies would collaborate closely with the Services, ODFW, and others in developing and managing the comprehensive Willamette Basin RM&E program. The coordinating mechanism would be the WATER RM&E Committee described in Section 2.6.

Throughout the preceding sections of this Section 2, the proposed action includes RM&E measures to evaluate respective elements of the proposed action. General RM&E recommendations are made in Section 2.8, Flow Management; Section 2.10, Hatchery Operations and Reform Actions; Section 2.11, Habitat Restoration and Management Actions; and Section 2.13, Water Quality Improvements. In each of these cases, the proposed RM&E activities can be characterized primarily as effectiveness monitoring tied to individual elements of the proposed actions. The overall intent of the RM&E program in those cases would be to determine whether or not measures and activities implemented to protect and restore ESA-listed species and their habitats are having the desired results and to make adaptive management adjustments to the measures as needed.

The Action Agencies propose a more comprehensive RM&E program as part of the system configuration feasibility studies described in Section 2.12, Structural Modifications. In that case adequate RM&E would be conducted to develop a life-cycle biological model that can be used to quantitatively evaluate the effects of a variety of different operational and structural alternatives against the baseline condition.

The Action Agencies do not have a single unified source of funding for implementation of a comprehensive RM&E program in the Willamette Basin. Funding for RM&E activities would be drawn from a variety of sources consistent with allocation of funding for the individual action areas. In all cases, the funding available for RM&E activities would be constrained.

The details of the program would be established in coordination with the Services in development of the WATER Charter. However, the Action Agencies describe a proposed process and framework in Section 3.8 of the Supplemental BA (USACE 2007a).

2.14.1 Coordination with the FCRPS RM&E Plan

Proposed Action: **The Action Agencies would coordinate the Willamette Project RM&E program activities with those of the FCRPS RM&E actions and results through participation in the USACE's Anadromous Fish Evaluation Program, Northwest Power and Conservation Council's Fish and Wildlife Program, Pacific Northwest Aquatic Monitoring Program, and Northwest Environmental Data network.**

As described in the Supplemental BA (USACE 2007a), the Action Agencies have developed an RM&E plan as part of their Proposed Action for continued operation of the FCRPS. The Willamette Project and FCRPS RM&E plans are interrelated in that proposed FCRPS Estuary and Ocean RM&E would provide information on the effects of FCRPS habitat and predator management actions on Willamette Chinook and steelhead ESUs. In addition, the FCRPS RM&E plan proposes other activities that may be directly applicable to Willamette Project RM&E, including standardization of tagging and monitoring methods, and development of a regionally coordinated information system. Lessons learned from other FCRPS RM&E actions, such as tributary and hatchery RM&E, may also be obtained. Coordination across the two RM&E efforts is needed to ensure that duplication of research does not occur, relevant results are shared, and lessons are learned.

2.14.2 Guiding Principles & Strategic Questions for RM&E Needs

Proposed Action: **The Action Agencies would work with the Services, ODFW, and others to articulate a clear and mutually supportable set of guiding principles and strategic questions to be used in developing, evaluating, and integrating RM&E needs associated with components of the Supplemental BA's revised proposed action and associated Biological Opinions related to the continuing operation of the Willamette Project.**

In the Supplemental BA (USACE 2007a), the Action Agencies propose guiding principles for the Willamette RM&E Program. The purpose of, and intended use for the guiding principles is to stimulate and guide cooperative thinking in identifying critical RM&E needs. This is an initial effort by the Action Agencies to lay the ground rules or framework for the future Willamette RM&E Program.

2.15 DESCRIPTION OF THE ACTION AREA

Based on the description of the proposed action in the preceding sections, the action under consideration affects a large area of the Willamette River Basin and lower Columbia River Basin, termed the "action area." An action area is defined in NMFS' regulations (50 CFR 402.02) as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." Direct effects may extend upstream or downstream based on the potential for impairing fish passage, flow, hydraulics, sediment and pollutant discharge, and the extent of riparian and instream habitat modifications. Indirect effects may occur throughout the watershed where the proposed action leads to additional activities or affects ecological functions that contribute to habitat degradation.

Willamette Project dams and reservoirs directly affect the channels and valley floodplains downstream as well as portions of upstream channels and valleys that are impounded. The Project indirectly affects stream reaches upstream that are or could otherwise be accessed and used by anadromous fish. The Willamette Project could have an indirect effect on the amount of marine derived nutrients returning to spawning and rearing areas due to a reduction in the number of adult fish returning to spawn and die.

- Therefore, for purposes of this consultation, the action area includes:
- All river reaches, riparian zones, and floodplain areas located downstream of the 13 Willamette Project dams, including the mainstem Willamette River and the tributaries on which these facilities are located (i.e., mainstem reaches of the North Santiam River, South Santiam River, Santiam River, McKenzie River, South Fork McKenzie River, Blue River, Fall Creek, Middle Fork Willamette River, Row River, Coast Fork Willamette River, and the Long Tom River), and the lower Columbia River from the confluence of the Willamette to the mouth of the Columbia River, including estuarine habitat in which listed salmonids and green sturgeon are affected by the Willamette Project (USACE 2000). This action area also encompasses the 42 miles of streambank revetments maintained by the USACE and the adjacent stream reaches affected by those revetments.
- The Molalla River from RM 20.2, the Calapooia River from approximately RM 0.5, and the Clackamas River from RM 20.1 to the confluence with the Willamette. These stream reaches include some of the 42 miles of streambank revetments maintained by the USACE.
- Stream reaches and land areas permanently or seasonally inundated by Willamette Project reservoirs in dry, average, and wet years.
- All reaches of tributaries located upstream of Willamette Project dams that are presently or were historically accessible to listed fish before construction of the 13 dams in the Willamette Project.
- Areas off the Pacific Coast where salmonid species from the Columbia River, which are affected by the Willamette Project, are available as prey for listed Southern Resident Killer Whales; generally within 50 km of the coast from the river's mouth and plume south to southern Oregon and north to the Queen Charlotte Islands.

Chapter 3
Rangewide Status

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3 RANGEWIDE STATUS

In step 1 of its analysis, NMFS defines the biological requirements and current status of each affected listed species and the conservation role and current function of any designated critical habitat. For salmon and steelhead species, this involves comparing the status of each ESU and its component populations and major population groups (MPGs), or strata, 1 to available viability criteria. Viability at the population scale is evaluated based on the viable salmonid population parameters of abundance, productivity, spatial structure, and diversity, which are used to assess population extinction risk (McElhany et al. 2000). At the MPG scale, viability is evaluated based on guidelines regarding how many and which populations should be at low risk for the MPG to be considered low risk. ESU or DPS viability is similarly evaluated based on guidelines that each MPG should be at low risk (WLCTRT and ODFW 2006, ICTRT 2007).

In assessing status, NMFS starts with the information used in its most recent decision to list for ESA protection the species considered in this Opinion, and also considers any more recent data that are relevant to the species' rangewide status. This step of the analysis tells NMFS how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity and identifies potential causes of the species' decline.

The following sections briefly describe the current status of the species (listing status, general life history, and population dynamics) in a manner relevant to each species' biological requirements.

3.1 RANGEWIDE STATUS OF THE SPECIES

Thirteen ESA-listed salmon and steelhead species (Table 3-1) are likely to be affected by this proposed action. In addition, green sturgeon and killer whales may be affected. Of these species, NMFS has determined that Upper Willamette River (UWR) Chinook salmon and UWR steelhead are likely to be most substantially affected by the proposed action because their spawning and rearing habitat, along with portions of their migratory habitat, are, and were historically, in close proximity to the Willamette Project dams, whereas the habitat of other

[1] The ESA defines a *species* to include any species, sub-species, or distinct population segment (ESA section (3)(15)). NMFS defines distinct population segments as Evolutionarily Significant Units (ESUs) for listing Pacific salmon (and previously used the term ESU for West Coast steelhead as well) (Waples 1991). An ESU is a group of Pacific salmon that is (1) substantially reproductively isolated from other groups and (2) represents an important component of the evolutionary legacy of the species. Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). Rainbow trout, the resident form of *O. mykiss*, are under the jurisdiction of the U.S. Fish and Wildlife Service. The Federal Register notice (71 FR 834) contains a more complete explanation of the listing decision and of previous ESA actions related to steelhead.

Each ESU or DPS is composed of a number of demographically independent populations. Independent populations are grouped into strata, or major population groups (MPGs), based on ecoregions and life history types. MPGs are thus groups of populations that share similar environments, life history characteristics, and geographic proximity (WLCTRT and ODFW 2006).

species affected is not in proximity to the dams. The following descriptions of rangewide status are thus most detailed for UWR Chinook salmon and UWR steelhead.

Table 3-1 shows listing status and date, date of critical habitat designation, and relevant Federal Register notices, for the 13 species of salmon and steelhead likely to be affected by the actions considered in this consultation. NMFS includes listing information for the green sturgeon and Southern Resident killer whale, but has determined that the Proposed Action and the RPA are not likely to adversely affect either species or critical habitat designated for the Southern Resident killer whale. Critical habitat has been designated for all these species except LCR coho salmon and the Southern DPS of green sturgeon.

Table 3-1 Listing status and critical habitat designations for species considered in this opinion. (Listing status: 'T' means listed as threatened under the ESA; 'E' means listed as endangered.)

SPECIES	LISTING STATUS	CRITICAL HABITAT
Chinook salmon (*Oncorhynchus tshawytscha*)		
Lower Columbia River	T: 6/28/05 (NMFS 20005c)	09/02/05 (NMFS 2005d)
Upper Willamette River	T: 6/28/05 (NMFS 2005c)	09/02/05 (NMFS 2005d)
Upper Columbia River spring-run	E: 6/28/05 (NMFS 2005c)	09/02/05 (NMFS 2005d)
Snake River spring/summer run	T: 6/28/05 (NMFS 2005c)	10/25/99 (NMFS 1999c)
Snake River fall-run	T: 6/28/05 (NMFS 2005c)	12/28/93 (NMFS 1993)
Chum salmon (*O. keta*)		
Columbia River	T: 6/28/05 (NMFS 2005c)	09/02/05 (NMFS 2005d)
Coho salmon (*O. kisutch*)		
Lower Columbia River	T: 6/28/05 (NMFS 2005c)	Not yet designated
Sockeye salmon (*O. nerka*)		
Snake River	E: 6/28/05 (NMFS 2005c)	12/28/93 (NMFS 1993)
Steelhead *(O. mykiss)*		
Lower Columbia River	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Upper Willamette River	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Middle Columbia River	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Upper Columbia River	E: 6/13/2007 (NMFS 1997)	09/02/05 (NMFS 2005d)
Snake River Basin	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Green Sturgeon *(Acipenser medirostris)*		
Southern DPS of Green Sturgeon	E: 4/7/06 (NMFS 2006c)	Not yet designated
Killer Whales *(Orcinus orca)*		
Southern Resident DPS Killer Whales	E: 11/18/05 (NMFS 2005e)	11/29/06 (NMFS 2006d)

3.2 Life Histories, Factors for Decline & Population Trends

The biological requirements, life histories, historical abundance, current viability, and factors contributing to the decline of salmon and steelhead species have been well documented. The following sections summarize relevant information from recent documents, most of which are available on the NMFS Northwest Regional or Northwest Fisheries Science Center websites (e.g., see Good et al. 2005; NMFS 2005c and 2006b; Myers et al. 2006; WLCTRT 2003 and 2004; WLCTRT and ODFW 2006; and McElhany 2007.

3.2.1 Upper Willamette River (UWR) Chinook Salmon

3.2.1.1 ESU Description

The UWR Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon, as well as UWR Chinook from seven artificial propagation programs (NMFS 2005c). The seven artificial propagation programs considered part of the ESU are the McKenzie River Hatchery (Oregon Department of Fish and Wildlife (ODFW) stock # 24), Marion Forks/North Fork Santiam River (ODFW stock # 21), South Santiam Hatchery (ODFW stock # 23) in the South Fork Santiam River, South Santiam Hatchery (ODFW stock # 23) in the Calapooia River, South Santiam Hatchery (ODFW stock # 23) in the Mollala River, Willamette Hatchery (ODFW stock # 22), and Clackamas hatchery (ODFW stock # 19) spring-run Chinook hatchery programs (NMFS 2005c).

The Willamette/Lower Columbia Technical Recovery Team (WLCTRT) identified seven independent populations within this ESU, as shown in Table 3-2 and Figure 3-1, below (Myers et al. 2006); all populations are part of the same stratum, or major population group (WLCTRT 2003).

Table 3-2 Historical populations in the UWR Chinook salmon ESU (Myers et al. 2006).

STRATUM	POPULATION*
Upper Willamette	Clackamas (C)
	Molalla
	North Fork Santiam (C)
	South Fork Santiam
	Calapooia
	McKenzie (C)(G)
	Middle Fork Willamette (C)

*The designations “C” and “G” identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

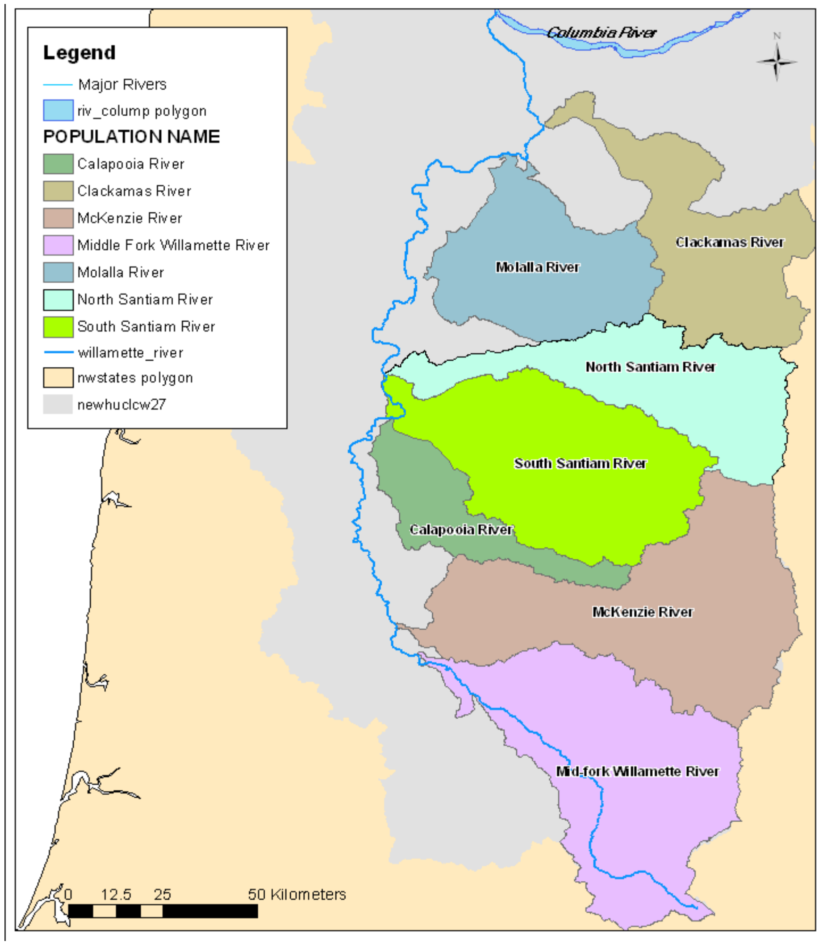
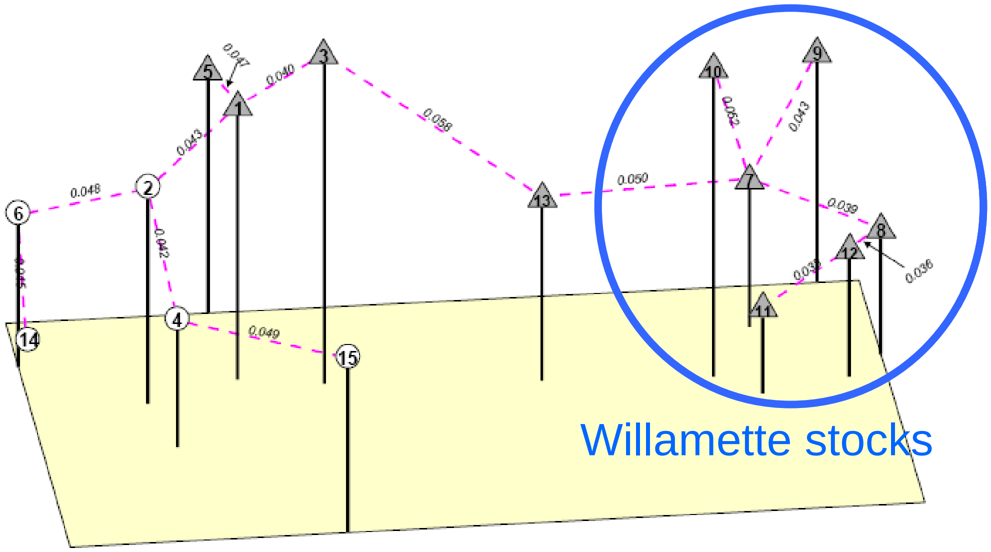


Figure 3-1 Map of historical populations in the UWR Chinook ESU (Myers et al. 2006)

UWR Chinook salmon are one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin. Historically (before the laddering of Willamette Falls), passage by returning adult salmonids over Willamette Falls (RKm 37) was possible only during the winter and spring high-flow periods. The early run timing of Willamette River spring-run Chinook salmon relative to other lower Columbia River spring-run populations is viewed as an adaptation to flow conditions at the falls. Since the Willamette Valley was not glaciated during the last epoch, the reproductive isolation provided by the falls was probably uninterrupted for a considerable time and provided the potential for significant local adaptation relative to other Columbia River populations (Myers et al. 2006). UWR Chinook salmon still contain a unique set of genetic resources compared to other Chinook stocks in the W/LC Domain (Figure 3-2; also see Myers et al. 1998 and Myers et al. 2006).



1. Cowlitz Hatchery spring
2. Cowlitz Hatchery fall
3. Kalama Hatchery spring
4. Kalama Hatchery fall
5. Lewis Hatchery spring
6. Lewis Hatchery fall
7. McKenzie and Dexter hatcheries spring
8. McKenzie River spring
9. North Santiam River spring
10. Clackamas Hatchery spring
11. North Fork Clackamas River spring
12. Marion Forks Hatchery spring
13. Sandy River spring
14. Sandy River fall
15. Spring Creek and Big Creek hatcheries

Figure 3-2 Three-dimensional representation of genetic difference, showing similarity of UWR Chinook stocks (indicated by proximity in the diagram) and their distinctness from Lower Columbia Chinook stocks (indicated by distance in the diagram). Figure adapted from Myers et al. 2006.

3.2.1.2 Life History

While adult UWR Chinook salmon begin appearing in the lower Willamette River in January, the majority of the run ascends the falls in April through May (Myers et al. 2006). Mattson (1963) discusses the existence of a late spring-run Chinook salmon that ascended the falls in June. These fish were apparently much larger and older (presumably 6 year olds) than the earlier part of the run. Mattson (1963) speculated that this portion of the run intermingled with the earlier-run fish on the spawning grounds and did not represent a distinct run. The disappearance of the June run in the Willamette River in the 1920s and 1930s was associated with a dramatic decline in water quality in the lower Willamette River.

Juvenile emigration patterns of the UWR Chinook salmon include traits from both ocean- and stream-type life histories. Smolt emigrations occur both as subyearlings, consistent with ocean-type life histories, and as yearlings, consistent with stream-type life histories, in the fall and spring (Schroeder and Kenaston 2004). While data are not available for all populations, available data indicate that the Clackamas, McKenzie, and Middle Fork Willamette populations have the greatest percentage of yearling migrants (Table 3-3).

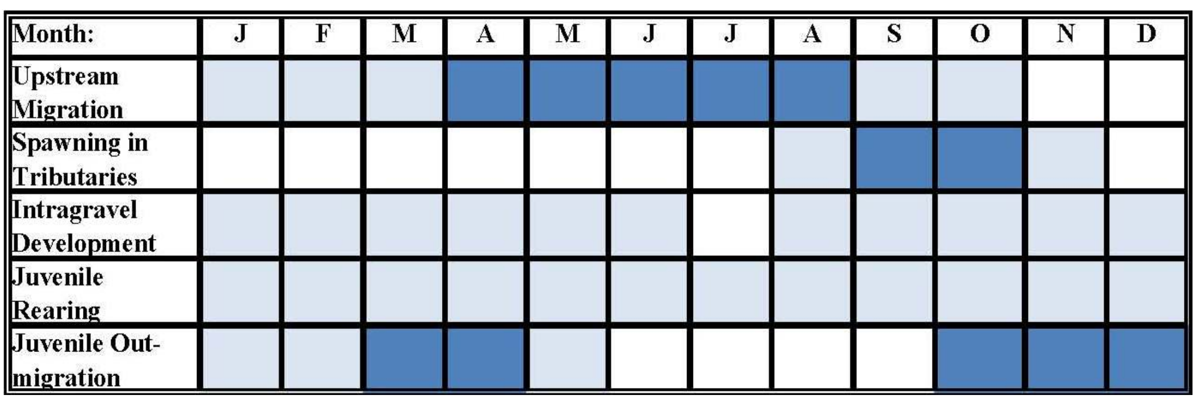
Table 3-3 Percentage of returning adult spring Chinook salmon that emigrated to saltwater as yearlings (adapted from Schroeder and Kenaston 2004).

	RUN YEAR	
Basin	**2002**	**2003**
Middle Fork Willamette*	94	
McKenzie	74	83
South Santiam	20	9
North Santiam	48	60
Clackamas	68	85

* Note that sample size for the Middle Fork Willamette was very small (18 fish), which could have resulted in a biased estimate.

Ocean distribution of this ESU is consistent with an ocean-type life history, with the majority of spring Chinook being caught off the coasts of British Columbia and Alaska. Spring Chinook from the Willamette River have the earliest return timing of all Chinook stocks in the Columbia Basin, with freshwater entry beginning in February. At present, adults return to the Willamette River primarily at ages 3 through 5 (ODFW 2008c), with age 4 fish being most abundant. Historically, age 5 fish were most abundant, and spawning occurred between mid-July and late October. The current spawn timing of both hatchery and natural-origin UWR Chinook is September and early October (Schroeder and Kenaston 2004). Table 3-4 shows generalized life history timing for UWR Chinook salmon.

Table 3-4 UWR Chinook salmon life history timing. Light shading represents low-level abundance and dark shading represents higher abundance (after USACE 2007a, Table 4-2). (Upstream migration in this table refers to adult presence in the mainstem Willamette and tributaries).



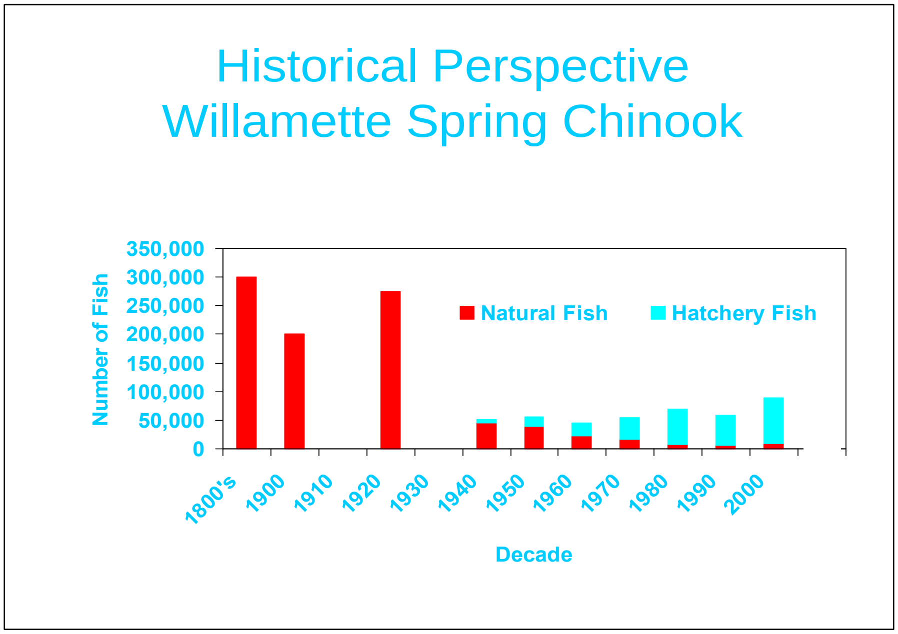


Figure 3-3 Historical abundance of wild spring Chinook salmon returns to the Willamette River. Abundances are aveaged by decade (Meyers et al. 2006).

3.2.1.3 Current Viability

Historically the Upper Willamette supported large numbers (perhaps exceeding 275,000 fish) of Chinook salmon (Figure 3-3; Myers et al. 2006). While counts of hatchery- and natural-origin adult spring Chinook salmon over Willamette Falls since 1946 have increased (Figure 3-4), approximately 90 percent of the return is now hatchery fish. Current abundance of wild fish is estimated to be less than 10,000, with significant natural production occurring only in two populations - and the McKenzie (McElhany et al. 2007). The Clackamas and McKenzie are the only two watersheds in the ESU where sufficient habitat is still accessible and of sufficient quality to produce significant numbers of natural-origin spring Chinook.

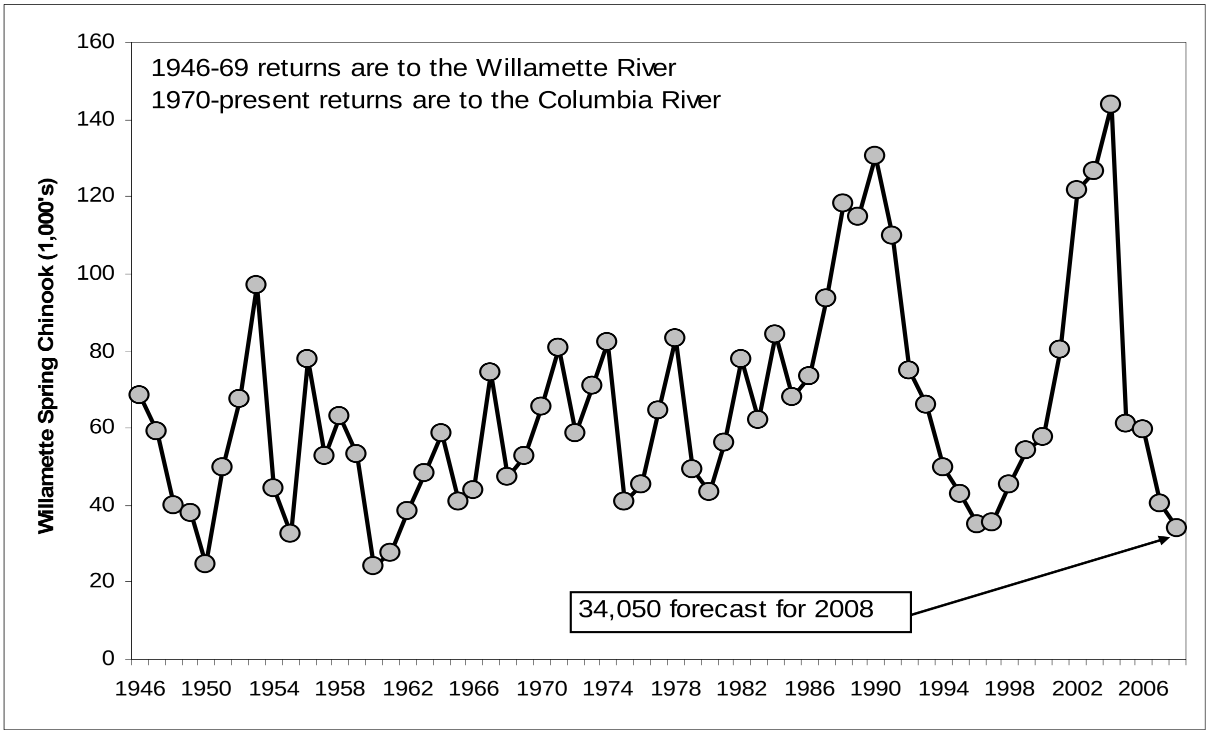


Figure 3-4 Total Willamette spring Chinook returns, (hatchery and wild fish combined) 1946-2007 and 2008 forecast[2] (ODFW 2008c).

The majority of the natural-origin populations in this ESU have very low current abundances (less than a few hundred fish), and high proportions of hatchery-origin spawners. Quantitative estimates of trends in abundance and adult returns per spawner are available only for the Clackamas and McKenzie Chinook populations. In both cases, as shown in Table 3-5, while the long-term trend in abundance is slightly higher than 1.0, long-term median population growth rates (lambda) are negative, as are recruits per spawner (Table 3-5) (McElhany et al. 2007).

[2] Figure uses 2 datasets. Prior to 1970, estimates are for fish returning to the Willamette (do not include fish harvested in ocean and Columbia). For 1970 – present, estimates are for Willamette fish entering the Columbia River (do not include fish harvested in ocean).

Table 3-5 Abundance, productivity, and trends of UWR Chinook populations (source: McElhany et al. 2007). 95% confidence intervals are shown in parentheses.

Population	Recent Natural Spawners			Long-Term Trend		Median Growth Rate		Recruits/spawner	
	Years[1]	No. [2]	pHOS[3]	Years	Value[4]	Years	λ[5]	Years	Value[6]
Clackamas	90-05	1656 (1122-2443)	47%	58-05	1.04 4 (1.033-1.055)	58-05	0.967 (0.849-1.102)	58-05	0.888 (0.667-1.182)
Molalla	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SF Santiam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Calapooia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
McKenzie	90-05	2104 (1484-2983)	33%	70-05	1.017 (0.994-1.04)	70-05	0.927 (0.761-1.129)	70-05	0.705 (0.485-1.024)
MF Willamette	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: Reported time series correspond to reported values in available information.
1 Years of data for recent means.
2 Geometric mean of natural-origin spawners.
3 Average recent proportion of hatchery-origin spawners
4 Long-term trend of natural-origin spawners (regression of log-transformed natural-origin spawner abundances against time).
5 Long-term median population growth rate after accounting for the relative reproductive success of hatchery-origin spawners compared to those of natural origin. The statistic is corrected for hatchery fish to model the growth rate of the natural population if there had been no hatchery supplementation (McElhany et al. 2007).
6 Geometric mean of recruits per spawner using all brood years in the analysis period.
N/A = not available

STRATUM	POPULATION	EXTINCTION RISK CATEGORY
Upper Willamette	Clackamas	Low
	Molalla	Very High
	NF Santiam	Very High
	SF Santiam	Very High
	Calapooia	Very High
	McKenzie	Moderate
	MF Willamette	Very High

Table 3-6 Risk of extinction categories for populations of UWR Chinook (source: McElhany et al. 2007).

Extinction risk for each population over a 100-year time frame (Table 3-6 and Figure 3-5) was estimated qualitatively, based on criteria identified by the WLCTRT (McElhany et al. 2007). The rating system categorized extinction risk as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. Based on the results for each population, McElhany et al. (2007) determined that the risk of extinction for the ESU was "high."

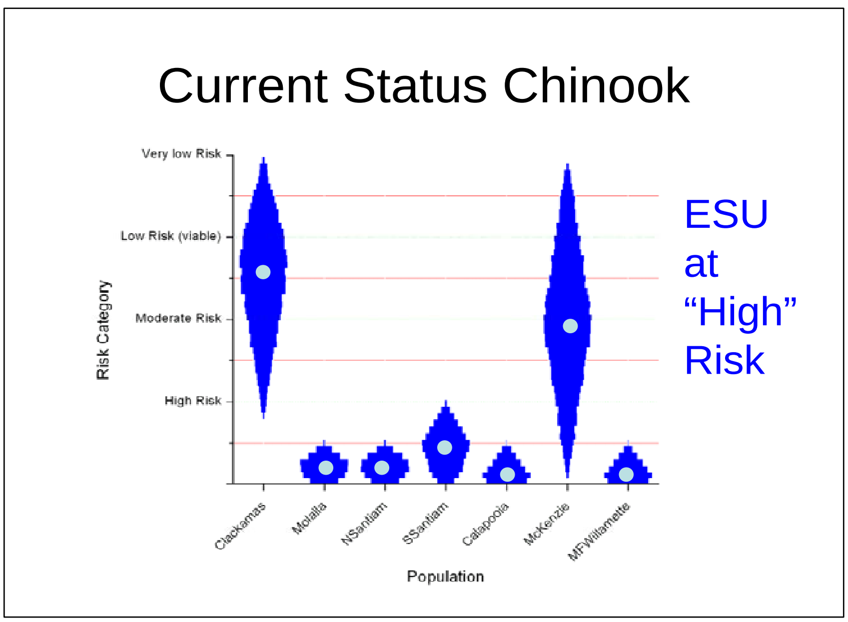


Figure 3-5 Current risk status of UWR spring Chinook salmon populations. Width of diamond corresponds with likelihood that the population is at status shown (McElhany et al. 2007).

All three of these metrics evaluate whether a population is maintaining itself, declining, or growing. A long-term trend > 1.0 indicates that population abundance is increasing over time, while a trend of <1.0 indicates abundance is decreasing. A median population growth rate (lambda) of 1.0 indicates a stationary population, lambda > 1.0 indicates that the population is growing, and lambda < 1.0 indicates a declining population. Similarly, recruits per spawner of 1.0 indicates that 100 parental spawners would produce 100 progeny that survive and spawn successfully, while values above and below 1.0 indicate that each parental spawner produces less than one successful spawner, or more than one successful spawner, respectively. The long-term trend calculation may be elevated by the way in which it includes the progeny of hatchery-origin spawners, whereas the lambda and recruits per spawner values assess how a population would perform in the absence of continued hatchery production (NMFS 2008a; McElhany et al. 2007).

Spatial structure, or geographic distribution, of the North Fork Santiam, South Fork Santiam, McKenzie, and Middle Fork Willamette populations has been substantially reduced by the loss of access to the upper portions of those tributary basins due to flood control and hydropower development, including dams owned and operated by the Corps. It is likely that genetic diversity has also been reduced by this habitat loss. The habitat conditions conducive to salmon survival in the Molalla and Calapooia subbasins have been reduced significantly by the effects of land use, including forestry, agriculture, and development. Spatial structure of the Clackamas population remains relatively intact (McElhany et al. 2007).

The diversity of some populations has been further eroded by hatchery and harvest influences and degraded habitat conditions in lower elevation reaches, all of which have contributed to low population sizes (McElhany et al. 2007). As described above, historically UWR Chinook had diverse life history types, with greater variation in the age structure and timing of both returning adults and out-migrating juveniles. At present, the life history diversity of all UWR Chinook populations has been significantly simplified because there is less variation in ages and run timing. The healthiest populations (Clackamas and McKenzie) still have life history characteristics representative of historical runs, although interbreeding with hatchery fish has likely resulted in genetic introgression over the last 50 years.

3.2.1.4 Limiting Factors

The factors that have caused the decline of this ESU to its threatened status and that are limiting the ESUs' ability to recover include multipurpose dams, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. These factors are summarized briefly below. Of these factors, harvest is believed to have been reduced to a point where it is no longer limiting recovery, based on assessments by the ODFW as part of its recovery planning process. Additional information on limiting factors is described for individual populations in the environmental baseline section of this Biological Opinion.

3.2.1.4.1 Tributary and Willamette River Mainstem Habitat

Habitat in the Willamette River mainstem and lower reaches of all the tributaries to the Willamette River is moderately to severely degraded. Specific habitat concerns vary by subbasin but include reduced habitat complexity, reduced access to off-channel habitat, reduced floodplain function and connectivity, loss of holding pools, elevated water temperatures, insufficient stream flows, toxic water pollutants, and altered substrate compositions. Some tributaries have numerous passage barriers. Habitat downstream of the dams has become the only area available for natural reproduction because so much of the ESU's historic habitat has been blocked by the Willamette Project dams. Habitat conditions above the dams in most of the upper tributaries, although not pristine, represent the best available habitat for spawning, incubation, and early rearing by spring Chinook (NMFS 2008a).

3.2.1.4.2 Estuary Habitat

Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats used extensively by subyearling juvenile migrants. The ocean survival of yearling juveniles can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to yearling migrants during transition to the ocean phase of their lifecycle; yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007c). Although it is highly unlikely that fish from this ESU encounter FCRPS mainstem projects, water management operations in the upper Columbia basin affect habitat and flow in the lower Columbia River, estuary, and plume (NMFS 2008a).

3.2.1.4.3 Multipurpose Dams

The Corps operates 13 dams in the largest five Willamette tributaries for multiple authorized and incidental purposes, including flood control, irrigation water supply, municipal and industrial water supply, navigation, flow augmentation, hydroelectric power, recreation, fish and wildlife conservation, and system operation. Impacts of these dams include blocked passage, poor downstream water quality, entrapment and stranding due to flood control and power peaking operations, and degraded functioning of downstream habitat. These effects are discussed extensively in the environmental baseline section. Adult and juvenile UWR Chinook also migrate past several smaller hydropower projects located below the Corps dams, which are licensed by the Federal Energy Regulatory Commission (FERC). These projects, which either have recently or are currently undergoing relicensing, are described in more detail in the environmental baseline section.

3.2.1.4.4 Harvest

UWR Chinook salmon are caught in ocean fisheries off southeast Alaska and northern Canada and in fisheries in the mainstem Columbia and Willamette rivers, and in Willamette River tributaries. The harvest rate on UWR Chinook salmon in ocean fisheries has averaged 11% in recent years. The total allowable harvest rate of unmarked Chinook in all freshwater fisheries is 15%, as specified in the Fisheries Management and Evaluation Plan (FMEP) for Willamette spring Chinook NMFS approved under ESA §4(d). [3] Only hatchery-origin Chinook (ODFW 2001a), which can be harvested in all freshwater fisheries affecting Willamette spring Chinook. Actual freshwater harvest on natural-origin Chinook has ranged from 9 to 12% in recent years.

3.2.1.4.5 Hatcheries Management

Hatcheries have been used as a management tool in the Willamette River basin for over 100 years, including use as mitigation for production lost due to dams. Hatchery-origin fish now outnumber natural-origin spawners in nearly all populations. All six of the Chinook populations above Willamette Falls and, to a lesser degree, the Clackamas population, are at risk for genetic introgression due to the high proportions of hatchery-origin fish on the spawning grounds (NMFS 2008a).

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[3] Significant reductions in fishing rates below 15% do not appreciably affect wild escapement or long-term probabilities of survival and recovery because fishing no longer affects significant numbers of wild fish, especially at low run sizes (ODFW 2001a)

3.2.1.4.6 Predation
Yearling smolts are vulnerable to bird predation in the estuary (Fresh et al. 2005). In addition, spring Chinook are subject to pinniped predation when they return to the estuary as adults (NMFS 2008a). Pikeminnows are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.1.4.7 Ocean & Climate
The analyses of UWR salmon and steelhead status in this Opinion generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average, and future trends are unclear. Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.1.5 Summary of Rangewide Status for UWR Chinook Salmon

The UWR Chinook salmon ESU is currently at a high risk of extinction. Five of the seven populations in the ESU are currently at very high risk of extinction, with one population (the McKenzie) at moderate risk, and one (the Clackamas) at low risk. Natural production in these populations averages a couple thousand fish annually. Limiting factors for this ESU have come from multiple sources, including tributary dams, hydropower development, habitat degradation, hatchery effects, past harvest management, and predation.

The Willamette Project dams have blocked access to major portions of historical spawning habitat for four populations (the McKenzie, North Santiam, South Santiam, and Middle Fork), and downstream affects of the dams have also adversely affected these populations. Spring Chinook return to freshwater several months prior to spawning and require cool stream temperatures and adequate holding pools as they spend the summer maturing to eventually spawn in September and October. This over-summering habitat has been dramatically altered by the Willamette Project dams because they (1) block access to the cooler, headwater habitat that was used historically by adult Chinook and (2) expose Chinook confined to areas below Project dams to unnatural temperature regimes, which increase both adult and egg mortality.

3.2.2 Upper Willamette River (UWR) Steelhead

3.2.2.1 DPS Description

The UWR steelhead distinct population segment (DPS) includes all naturally spawned anadromous winter-run steelhead populations in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive). There are no hatchery programs included in this ESU (NMFS 2006b). The hatchery summer-run steelhead that occur in the Willamette Basin are an out-of-basin stock and not considered part of the DPS.

The WLCTRT identified four historical independent populations within this DPS, all of which are part of one major population group, as shown in Table 3-7 and Figure 3-6 (Myers et al. 2006).

Table 3-7 Historical populations in the UWR steelhead DPS (Myers et al. 2006).

Stratum	Population*
Upper Willamette	Molalla
	North Santiam (C*), (G)
	South Santiam (C), (G)
	Calapooia

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

Although spawning winter steelhead have been reported in the west-side tributaries to the Willamette River, these tributaries are not considered to have constituted an independent population historically (Myers et al. 2006). These tributaries may, however, serve as a population sink for the DPS, meaning that, although they do not sustain (and are not believed to have historically sustained) an independent population, winter steelhead may intermittently utilize them for spawning or rearing.

3.2.2.2 Life History

Generalized life-history timing for UWR steelhead is shown in Table 3-8. Winter-run steelhead enter the Willamette River beginning in January and February but do not ascend to their spawning areas until late March or April. Spawning takes place from April to early June (Myers et al. 2006).

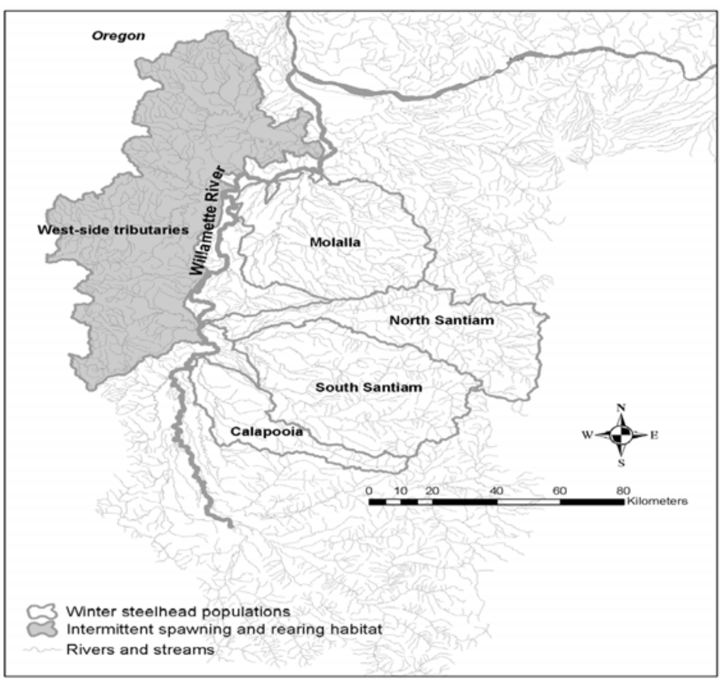

Figure 3-6 Historical populations in the UWR steelhead DPS. The west-side tributaries were not designated as an independent population but are included because of their importance to the DPS as a whole (Myers et al. 2006).

Table 3-8 UWR steelhead life history timing. Light shading represents low-level abundance and dark shading represents higher abundance (after USACE 2007a, Table 4-4).

MONTH:	J	F	M	A	M	J	J	A	S	O	N	D
Upstream Migration	light	light	dark	dark	light	light	light					
Spawning in Tributaries			light	dark	dark	light	light	light				
Intragravel Development			light	light	light	light	light					
Juvenile Rearing	light	light	light	light	light	light	light	light	light	light	light	light
Juvenile Out-migration			dark	dark	dark	light	light					

3.2.2.3 Current Viability

Numbers of steelhead in this DPS are depressed from historical levels, but to a much lesser extent than spring Chinook in the Willamette basin (McElhany et al. 2007). All of the historical populations produce moderate numbers of returning adults each year. While long-term trends are less than one (Table 3-9), short-term trends are 1.0 or higher (McElhany et al. 2007), indicating that, in the short-term (i.e., 1990-2005), abundance is increasing on average and the populations are growing.

Table 3-9 Abundance, productivity, and trends of UWR steelhead populations. 95% confidence intervals are shown in parentheses (source: McElhany et al. 2007).

POPULATION	RECENT NATURAL SPAWNERS			LONG-TERM TREND		MEDIAN GROWTH RATE		RECRUITS/SPAWNER	
	Years[1]	No. [2]	pHOS[3]	Years	Value[4]	Years	λ[5]	Years	Value[6]
Molalla	90-05	914 (655-1275)	0%[7]	80-05	0.966 (0.931-1.002)	80-05	0.988 (0.79-1.235)	80-05	0.985 (0.64-1.517)
North Santiam	90-05	2109 (1485-2994)	0%[7]	80-05	0.98 (0.946-1.014)	80-05	0.983 (0.786-1.231)	80-05	0.886 (0.59-1.331)
South Santiam	90-05	2149 (1618-2853)	0%[7]	68-05	0.984 (0.965-0.998)	68-05	0.976 (0.855-1.114)	80-05	0.962 (0.714-1.295)
Calapooia	90-05	339 (206-560)	0%[7]	80-05	0.987 (0.94-1.037)	80-05	1.023 (0.743-1.409)	80-05	1.126 (0.617-2.055)

Note: Reported time series correspond to reported values in available information.
1 Years of data for recent means.
2 Geometric mean of total spawners.
3 Average recent proportion of hatchery origin spawners
4 Long-term trend of natural spawners (regression of log-transformed spawner abundances against time); indicates rate of return of adults to spawners.
5 Long-term median population growth rate after accounting for the relative reproductive success of hatchery-origin spawners compared to those of natural origin (in this analysis, equal reproductive success was assumed).
6 Geometric mean of recruits per spawner using all brood years in the analysis period.
7Current hatchery fractions reflect termination of hatchery winter steelhead releases into natural production areas in the 1990s.
N/A = not available

Table 3-10 Risk of extinction categories for populations of UWR steelhead (source: McElhany et al. 2007).

STRATUM	POPULATION	EXTINCTION RISK CATEGORY
Upper Willamette	Molalla	Moderate
	North Santiam	Moderate
	South Santiam	Moderate
	Calapooia	Moderate

Extinction risk for each population over a 100-year time frame (Table 3-10 and Figure 3-7) was derived qualitatively, based on criteria identified by the WLCTRT (2004). The rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population. Based on these results, McElhany et al. (2007) determined that the risk of extinction for the DPS was "moderate."

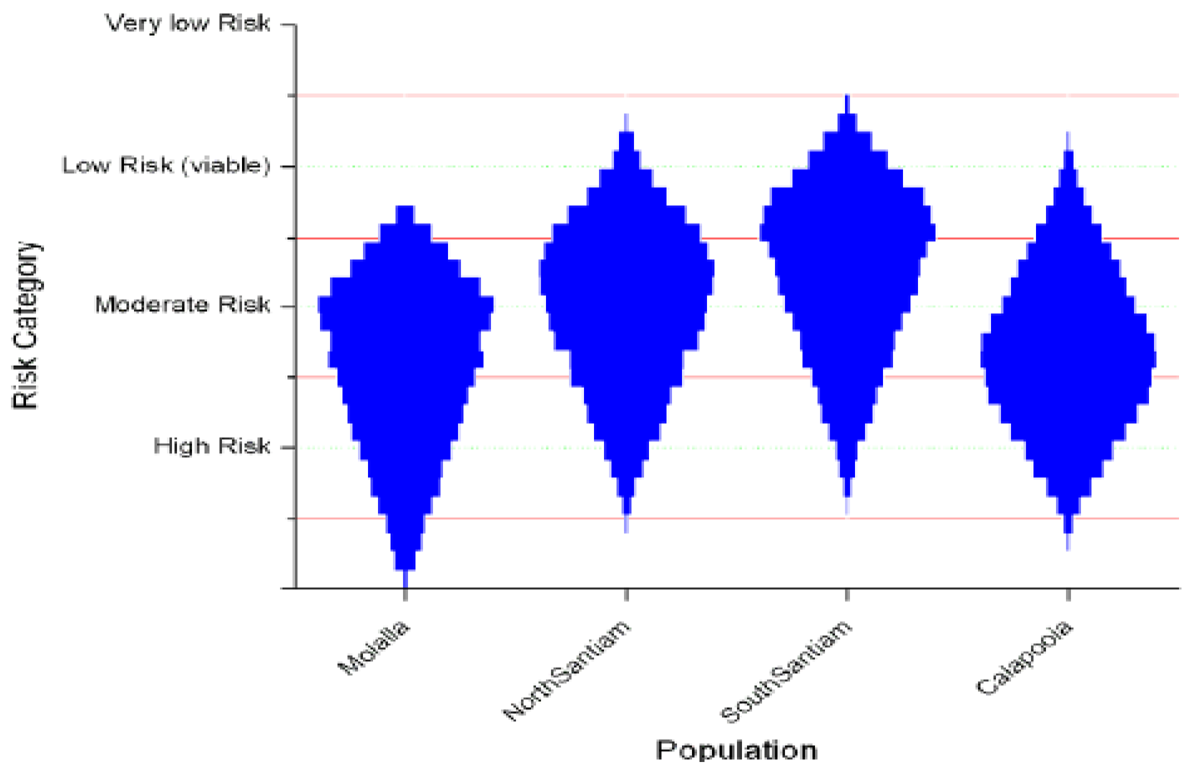

Figure 3-7 Current risk status of UWR steelhead populations. Width of diamond corresponds with likelihood that the population is at that particular status (McElhany et al. 2007).

Spatial structure for the North and South Santiam populations has been substantially reduced by loss of access to the upper North Santiam basin and the Quartzville Creek watershed in the South Santiam subbasin due to construction of the Corps dams (McElhany et al. 2007). Spatial structure in the Molalla subbasin has been reduced significantly by habitat degradation and in the Calapooia by habitat degradation and passage barriers (WLCTRT 2004).

The diversity of all four populations has been eroded by various factors including small population size, the loss of access to historic habitat, long-term effects of past winter-run hatchery releases, and the ongoing release of summer steelhead (McElhany et al. 2007).

3.2.2.4 Limiting Factors

The factors that have caused the decline of this DPS to its threatened status and that are limiting the DPS's ability to recover include multipurpose dams, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. These factors are summarized briefly below. Of these factors, harvest is considered reduced to a point where it is no longer limiting recovery, based on assessments done by the Oregon Department of Fish and Wildlife as part of its recovery planning process. Additional information on limiting factors is described for individual populations in the environmental baseline section of this Biological Opinion.

3.2.2.4.1 Tributary & Willamette Mainstem Habitat

Habitat in the lower reaches of all the tributaries to and in the mainstem of the Willamette River is moderately to severely degraded. Specific habitat concerns vary by subbasin but include impaired access in small streams, fine sediments in spawning gravel, reduced habitat complexity, reduced access to off-channel habitat, reduced floodplain function and connectivity, elevated water temperatures, water pollutants, and insufficient stream flows. Some tributaries have numerous small passage barriers. Habitat downstream of the dams has become more significant to the viability of the UWR steelhead DPS since significant portions of its historic habitat has been blocked by the Willamette Project dams. Conditions above the dams in most tributary subbasins, although not pristine, are adequate for steelhead production (NMFS 2008a).

3.2.2.4.2 Estuary Habitat

The ocean survival of yearling juveniles can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to yearling migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Although it is highly unlikely that fish from this DPS encounter FCRPS mainstem projects, water management operations in the upper Columbia basin affect habitat and flow in the lower Columbia River, estuary, and plume (NMFS 2008a). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007c).

3.2.2.4.3 Multipurpose Dams

The Corps operates 13 dams in the largest five Willamette tributaries for multiple authorized and incidental purposes, including flood control, irrigation water supply, municipal and industrial water supply, navigation, flow augmentation, hydroelectric power, recreation, fish and wildlife conservation, and system operation. Impacts of these dams include blocked passage, poor downstream water quality, entrapment and stranding due to flood control and power peaking operations, and degraded functioning of downstream habitat. These effects are discussed extensively in the environmental baseline section. UWR steelhead also pass several smaller hydropower projects licensed by FERC. These projects, which either have recently or are currently undergoing relicensing, are described in more detail in the environmental baseline section.

3.2.2.4.4 Harvest

Ocean fishing mortality on UWR steelhead is assumed to be zero. Incidental by-catch of steelhead in ocean fisheries is rare. Freshwater fisheries affecting UWR steelhead are managed according to a Fisheries Management and Evaluation Plan (FMEP) approved by NMFS under ESA section 4(d). This FMEP requires the release of all unmarked steelhead in lower Columbia, Willamette, and tributary fisheries. Since these fisheries are all catch and release, harvest impacts have been less than 2% in recent years.

3.2.2.4.5 Hatcheries

There are no winter steelhead hatchery programs in the Upper Willamette basin, but a non-native summer steelhead hatchery program creates threats to listed winter steelhead. Although there is some separation in run and spawn timing between hatchery-origin summer and wild winter steelhead, the potential exists for genetic introgression. Competition for rearing resources and spawning sites may also occur between hatchery-origin summer steelhead and wild winter steelhead (NMFS 2008a).

3.2.2.4.6 Predation

Stream-type juveniles, especially yearling smolts such as steelhead, are vulnerable to bird predation in the estuary (Fresh et al. 2005). In addition, steelhead are subject to pinniped predation when they return to the estuary as adults although the magnitude of pinniped predation for Upper Willamette fish is unknown (NMFS 2008a). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.2.4.7 Ocean & Climate

Analyses of Upper Willamette River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments (LCFRB 2004). However, until recently, ocean and climate conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in salmonid production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.2.5 Summary of Rangewide Status

The Upper Willamette winter steelhead DPS is currently at a moderate risk of extinction. All four of the populations in the DPS are currently at moderate risk. Limiting factors for this ESU have come from multiple sources, including tributary dams, habitat degradation, hatchery effects, past harvest management, and predation.

Winter steelhead have different life history requirements than spring Chinook, which could explain their reduced extinction risk. They migrate into the Willamette River from December through April, when stream temperatures are cold, and spawn almost immediately upon reaching spawning grounds. Their spawning habitat is also more widespread than that of spring Chinook: they spawn in the mainstems of the Molalla, North Santiam, South Santiam, and Calapooia rivers, as well as in small tributaries to those rivers. This more diverse spawning habitat lessens the risk to the populations overall. Winter steelhead have also not been as adversely affected by the Willamette Project dams as spring Chinook because they are not as dependent upon the headwater habitat above the dams for holding and spawning. In addition, since steelhead spawning is more widespread, these fish are not as susceptible to the direct effects of the dams (unlike spring Chinook, which, if they are not transported above the dams, must spawn in the mainstem rivers directly below the dams, where altered flows and water temperature affect their spawning success).

3.2.3 Lower Columbia River Salmon & Steelhead Species

Lower Columbia River (LCR) Chinook salmon, LCR coho salmon, and Columbia River (CR) chum salmon spawn and rear in Columbia River tributaries from Hood River and the White Salmon River downstream to the mouth of the Columbia River. LCR steelhead spawn and rear in Columbia River tributaries between the Wind and Cowlitz rivers (inclusive) in Washington and between the Hood and Willamette rivers (inclusive) in Oregon. The range of all four LCR species also includes, or historically included, the Clackamas River, which is a Willamette River tributary. Fish from these ESUs and DPS' also use, or used historically, the lower Willamette River mainstem as rearing and/or migratory habitat. These species are likely to be affected by the proposed action, but to a lesser extent than the two Upper Willamette species.

3.2.3.1 Lower Columbia River Chinook Salmon

The Lower Columbia River (LCR) Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from the mouth of the Columbia River upstream to and including the White Salmon River in Washington and the Hood River in Oregon, and including the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), as well as seventeen artificial propagation programs (NMFS 2005c). The LCR Chinook salmon ESU exhibits three major life history types: fall-run ("tules"), late fall-run ("brights"), and spring-run (Good et al. 2005).

The WLCTRT identified 32 historical independent populations within this ESU, divided into 6 major population groups as shown in Table 3-11 (Myers et al. 2006).

Table 3-11 Historical populations in the LCR Chinook salmon ESU (Myers et al. 2006).

MAJOR POPULATION GROUP	POPULATION*
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, Lewis (C), Sandy (C,G)
Gorge Spring	(Big) White Salmon (C), Hood
Coastal Fall	Grays, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose
Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy
Cascade Late Fall	Lewis (C,G), Sandy (C,G)
Gorge Fall	Lower Gorge, Upper Gorge (C,G), (Big) White Salmon (C,G), Hood

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2.3.1.1 Current Viability

Data for this ESU are limited, but available data indicate that many populations currently have low abundance. Where data allow calculation of abundance trends for individual populations, those trends are mostly negative, some severely so. Assuming that the reproductive success of hatchery-origin fish has been equal to that of natural-origin fish, analysis indicates a negative long-term growth rate for all populations except the Coweeman River fall run (Good et al. 2005).

While the spatial structure of some populations in this ESU is similar to historical conditions, spatial structure of many populations has been significantly impaired either by numerous small habitat blockages, tributary hydropower development (primarily in the White Salmon, Hood, Lewis, and Cowlitz rivers) or, for populations spawning above Bonneville Dam, by inundation of historic habitat. Diversity of most fall-run populations has been eroded by large hatchery influences and periodically low effective population sizes. In contrast, hatchery programs for spring Chinook salmon are preserving the genetic legacy of populations that were extirpated from blocked areas (WLCTRT 2004).

Extinction risk over a 100-year time frame (Table 3-12) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 3-12 Risk of extinction (in 100 years) for populations of LCR Chinook salmon (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Type	Strata	Population	State	Extinction Risk Category
Spring	Cascade	Cowlitz	W	High
		Cispus	W	High
		Tilton	W	Very High
		Toutle	W	Very High
		Kalama	W	Very High
		NF Lewis	W	Very High
		Sandy	O	Moderate
	Gorge	(Big) White Salmon	W	Very High
		Hood	O	Very High
Fall	Coastal	Grays/Chinook	W	High
		Elochoman/Skamokawa	W	High
		Mill/Abernathy/Germany	W	High
		Youngs Bay	O	Very High
		Big Creek	O	Very High
		Clatskanie	O	High
		Scappoose	O	Very High
	Cascade	Lower Cowlitz	W	High
		Upper Cowlitz	W	Very High
		Toutle	W	High
		Coweeman	W	Moderate
		Kalama	W	High
		Lewis	W	Moderate
		Salmon	W	Very High
		Washougal	W	High
		Clackamas	O	Very High
		Sandy	O	Very High
	Gorge	Lower Gorge	W/O	High/Very High
		Upper Gorge	W/O	High/Very High
		(Big) White Salmon	W	High
		Hood River	O	Very High
Late Fall	Cascade	NF Lewis	W	Moderate
		Sandy	O	Low

3.2.3.1.2 Limiting Factors

Limiting factors for this ESU are summarized below. For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004). (Oregon is currently developing a recovery plan for LCR Chinook salmon that spawn in Oregon tributaries.)

3.2.3.1.3 Tributary Habitat

Widespread urban development and other land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats where fall Chinook salmon spawn and rear (NMFS 2008a).

3.2.3.1.4 Estuary Habitat

Alterations in flow and diking have resulted in the loss of shallow water, low velocity habitats used extensively by subyearling juveniles, such as fall and late-fall LCR Chinook salmon. The ocean survival of yearling juveniles (juvenile Chinook from spring-run populations) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to yearling migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007b).

3.2.3.1.5 Multipurpose Dams

Federal Columbia River Hydropower System impacts on populations originating downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The five LCR Chinook salmon populations that spawn above Bonneville Dam have been affected by upstream and downstream passage at the dam and by inundation of tributary spawning habitat.

Tributary dams in the White Salmon, Hood, Lewis, Cowlitz, Sandy, and Clackamas basins have affected populations in those tributaries (NMFS 2008a), although many of those effects are being addressed as a result of recent FERC re-licensing and associated ESA consultations. Removal of Condit Dam is expected to support restoration of the spring and fall run Chinook populations in the White Salmon River (NMFS 2006e). Removal of Powerdale Dam is expected to support the restoration of the spring and fall fun Chinook populations in the Hood River (NMFS 2005f). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the spring run (NMFS 2007b). Upstream and downstream passage facilities will be developed at the Cowlitz River Hydroelectric Project (NMFS 2004a), allowing restoration of the Cispus Spring run, Tilton spring run, and Upper Cowlitz spring and fall run populations. Removal of Marmot and Little Sandy dams in the Sandy Basin will improve access for spring Chinook salmon into the upper Sandy watershed (NMFS 2003a).

3.2.3.1.6 Harvest

LCR Chinook salmon are harvested in the Columbia River and its tributaries and in ocean fisheries off Oregon, Washington, and Canada. Permitted harvest rate limits for fall-run Chinook salmon have dropped from 65% just after listing to 42% in 2007. Harvest rates on spring-run fish have been reduced from 50 to 25% (NMFS 2008a).

3.2.3.1.7 Hatcheries Practices

Hatchery management practices have reduced the diversity and productivity of natural populations in this ESU, especially the tule fall Chinook populations. For LCR spring Chinook salmon, virtually all production is of hatchery origin (NMFS 2008a).

3.2.3.1.8 Predation

Yearling smolts from spring-run populations are vulnerable to bird predation in the estuary (Fresh et al. 2005). In addition, spring Chinook are subject to pinniped predation when they return to the estuary as adults (NMFS 2007c). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.3.1.9 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids and the long-term average and future trends are unclear (NMFS 2007a). Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.3.2 Lower Columbia River Coho Salmon

The Lower Columbia River (LCR) coho salmon ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia up to and including the White Salmon and Hood rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as twenty-five artificial propagation programs (NMFS 2005c). Juvenile LCR coho salmon migrate to the ocean as yearlings from mid-April through the end of May with peak migrations during May. Adult LCR coho salmon typically migrate through the lower Columbia River from September through November.

The WLCTRT identified 24 historical populations in this ESU, grouped into three major population groups as shown in Table 3-13.

Table 3-13 Historical populations in the LCR coho salmon ESU (Myers et al. 2006).

STRATUM	POPULATION
Coast	Grays, Elochoman, Mill Creek, Youngs Bay, Big Creek, Clatskanie, Scappoose Creek
Cascade	Lower Cowlitz, Coweeman, SF Toutle, NF Toutle, Upper Cowlitz, Cispus, Tilton, Kalama, NF Lewis, EF Lewis, Salmon Creek, Washougal, Clackamas, Sandy
Gorge	Lower Gorge, Washington Upper Gorge and (Big)White Salmon River, Oregon Upper Gorge and Hood River

3.2.3.2.1 Current Viability

Data on LCR coho salmon are limited. In most cases, populations have low current abundance and high proportions of hatchery-origin spawners. Spatial structure of most populations has been impaired either by loss of habitat, small blockages or major tributary hydropower development (primarily in the White Salmon, Hood, Lewis, and Cowlitz rivers). The diversity of populations has been eroded by large hatchery influences and periodically low effective population sizes. (The genetic legacy of the Lewis and Cowlitz River coho populations is preserved in ongoing hatchery programs.)

Extinction risk over a 100-year time frame (Table 3-14) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 3-14 Risk of extinction in 100 years categories for populations of LCR coho (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

STRATUM	POPULATION	STATE	EXTINCTION RISK CATEGORY
Coast	Grays	W	High
	Elochoman	W	High
	Mill Creek	W	High
	Youngs Bay	O	Very High
	Big Creek	O	Very High
	Clatskanie	O	High
	Scappoose	O	High
Cascade	Lower Cowlitz	W	High
	Coweeman	W	High
	SF Toutle	W	High
	NF Toutle	W	High
	Upper Cowlitz	W	Very High
	Cispus	W	Very High
	Tilton	W	Very High
	Kalama	W	High
	NF Lewis	W	High
	EF Lewis	W	High

STRATUM	POPULATION	STATE	EXTINCTION RISK CATEGORY
	Salmon	W	Very High
	Washougal	W	High
	Clackamas	O	Low
	Sandy	O	High
Gorge	Lower Gorge	O/W	Very High/High
	WA Upper Gorge and White Salmon River	W	Very High
	OR Upper Gorge and Hood River	O	Very High

3.2.3.2.2 Limiting Factors

Limiting factors for this ESU are summarized below. For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004). (Oregon is currently developing a recovery plan for LCR coho salmon that spawn in Oregon tributaries.)

3.2.3.2.3 Tributary Habitat

Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting coho salmon in most lower Columbia River subbasins, particularly in low to moderate elevation habitats (NMFS 2008a).

3.2.3.2.4 Estuary Habitat

The ocean survival of yearling juveniles (such as LCR coho) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to coho migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007c).

3.2.3.2.5 Multipurpose Dams

Impacts of the Federal Columbia River Hydropower System on LCR coho populations spawning downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The two populations that spawn upstream of Bonneville Dam are affected by upstream and downstream passage at Bonneville Dam and by inundation of historic habitat (WLCTRT 2004 and McElhany et al. 2007).

Tributary dams in the White Salmon, Hood, Lewis, Cowlitz, Sandy, and Clackamas basins have affected populations in those tributaries (NMFS 2008a), although many of those effects are being addressed as a result of recent FERC re-licensing and associated ESA consultations. Removal of Condit Dam by 2009 is expected to support restoration of the White Salmon River portion of the WA Upper Gorge coho population (NMFS 2006e). Removal of Powerdale Dam is expected to support restoration of the Hood River portion of the OR Upper Gorge coho population (NMFS 2005f). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the NF Lewis River coho population (NMFS 2008a). Upstream and downstream passage facilities will be developed at the Cowlitz River Hydroelectric Project (NMFS 2004a), supporting restoration of the Cowlitz, Cispus, and Tilton coho populations. Removal of Marmot and Little Sandy dams in the Sandy Basin will improve passage for the coho population into the upper Sandy watershed (NMFS 2003a).

3.2.3.2.6 Harvest

Lower Columbia River coho are harvested in the ocean and in Columbia River and tributary freshwater fisheries of Oregon and Washington. Harvest rates on coho salmon prior to the 1990s fluctuated from approximately 60 to 90%, but have been reduced since listing to 15 to 25% (NMFS 2008a).

3.2.3.2.7 Hatchery Practices

Hatchery management practices have reduced the diversity and productivity of natural populations throughout the Columbia River Basin. LCR coho salmon populations have been heavily influenced by hatchery production over the years (NMFS 2008a).

3.2.3.2.8 Predation

As stream-type juveniles, coho are vulnerable to bird predation in the estuary (Fresh et al. 2005). Pikeminnow are also significant predators of stream-type migrants (Friesen and Ward 1999).

3.2.3.2.9 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions.

3.2.3.3 Lower Columbia River Steelhead

The LCR steelhead DPS includes all naturally produced steelhead in tributaries to the Columbia River between the Cowlitz and Wind Rivers (inclusive) in Washington and the Willamette and Hood Rivers (inclusive) in Oregon, excluding steelhead in the upper Willamette River above Willamette Falls (NMFS 2006b). Ten artificial propagation programs are also included in the ESU. Two distinct races of steelhead, summer and winter, historically were and currently are found in the lower Columbia River (Myers et al. 2006).

The WLCTRT identified 23 historical populations within the DPS, which were divided into 4 major population groups as shown in Table 3-15 (Myers et al. 2006).

Table 3-15 Historical populations in the LCR steelhead ESU (Myers et al. 2006).

MAJOR POPULATION GROUP	POPULATION*
Cascade Summer	Kalama (C), NF Lewis, EF Lewis (G), Washougal (C,G)
Gorge Summer	Wind (C), Hood
Cascade Winter	Lower Cowlitz, Coweeman, NF Toutle (C), SF Toutle, Coweeman, Upper Cowlitz (C,G), Lower Cowlitz, Cispus (C), Tilton, Kalama, NF Lewis (C), EF Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge Winter	Lower Gorge, Upper Gorge, Hood (C,G)

*The designations "C" and "G" identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2.3.3.1 Current Viability

Many populations in this DPS are small and have negative long- and short-term trends in abundance. In addition, for most populations the probability is high that the true growth rate is less than one (Good et al. 2005). Spatial structure of most populations has been impaired either by loss of habitat, small blockages or major tributary hydropower development (primarily in the Hood, Lewis, and Cowlitz rivers). The diversity of populations has been eroded by large hatchery influences; a number of the populations have a substantial fraction of hatchery-origin spawners and are thought to be largely sustained by hatchery production.

Extinction risk over a 100-year time frame (Table 3-16) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT's rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 3-16 Risk of extinction categories for populations of LCR steelhead (sources: Washington's Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Type	Strata	Population	State	Extinction Risk Category
Summer	Cascade	Kalama	W	High
		NF Lewis	W	Very High
		EF Lewis	W	High
		Washougal	W	High
	Gorge	Wind	W	Moderate
		Hood	O	Very High

Type	Strata	Population	State	Extinction Risk Category
Winter	Cascade	Lower Cowlitz	W	High
		Coweeman	W	High
		NF Toutle	W	High
		SF Toutle	W	Moderate
		Upper Cowlitz	W	High
		Cispus	W	High
		Tilton	W	Very High
		Kalama	W	Moderate
		NF Lewis	W	High
		EF Lewis	W	High
		Salmon	W	High
		Washougal	W	High
		Clackamas	O	Low
		Sandy	O	High
	Gorge	Lower Gorge	W/O	High/High
		Upper Gorge	W/O	High/Moderate
		Hood	O	Moderate

3.2.3.3.2 Limiting Factors

Limiting factors for this DPS are summarized below. For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004). (Oregon is currently developing a recovery plan for LCR steelhead that spawn in Oregon tributaries.)

3.2.3.3.3 Tributary Habitat

Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in low to moderate elevation habitats (NMFS 2008a).

3.2.3.3.4 Estuary Habitat

The ocean survival of yearling juveniles (such as LCR steelhead) can be affected by estuary factors such as changes in food availability and the presence of contaminants. Characteristics of the plume are also thought to be significant to coho migrants during transition to the ocean phase of their lifecycle, because yearling migrants appear to use the plume as habitat, in contrast to sub-yearlings, which stay closer to shore (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in the estuary module of the comprehensive regional planning process (NMFS 2007c).

3.2.3.3.5 Multipurpose Dams

Impacts of the FCRPS on LCR steelhead populations spawning downstream of Bonneville Dam are limited to effects on migration and habitat conditions in the Columbia River below Bonneville and in the estuary. The four populations that spawn upstream of Bonneville Dam are affected by upstream and downstream passage at Bonneville Dam and by inundation of historic habitat (McElhany et al. 2007 and WLCTRT 2004). Winter steelhead populations have also been blocked from higher elevation spawning habitats by construction of FERC-licensed hydropower facilities (NMFS 2008a), although many of those effects are being addressed as a result of recent FERC relicensing and associated ESA consultations. Removal of Marmot Dam will improve passage for the winter-run steelhead population into the upper Sandy River watershed (NMFS 2003a). Upstream and downstream passage facilities will be developed at the Lewis River Hydroelectric Project, a first step toward restoring the North Fork Lewis winter-run steelhead population (NMFS 2007b). Upstream and downstream passage facilities will also be developed at the Cowlitz River Hydroelectric Project, supporting the restoration of the Upper Cowlitz, Tilton, and Cispus winter-run steelhead populations (NMFS 2004a).

3.2.3.3.6 Harvest

LCR steelhead are harvested in Columbia River and tributary freshwater fisheries in Oregon and Washington. Fishery impacts on wild LCR steelhead have been limited to less than 10% since the implementation of mark-selective fisheries in the 1980s (NMFS 2008a).

3.2.3.3.7 Hatchery Practices

Hatchery management practices have reduced the diversity and productivity of natural populations throughout the Columbia River Basin (NMFS 2008a).

3.2.3.3.8 Predation

Stream-type juveniles, especially steelhead smolts, are vulnerable to bird predation in the estuary (Fresh et al. 2005). Steelhead are also subject to pinniped predation when they return to the estuary as adults (NMFS 2007c). Pikeminnow are significant predators of both yearling and subyearling juvenile migrants (Friesen and Ward 1999).

3.2.3.3.9 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in steelhead production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions (NMFS 2008a)

3.2.3.4 Columbia River Chum Salmon

The Columbia River chum ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon (NMFS 1999b). Three artificial propagation programs are also part of the ESU. Adult CR chum salmon typically enter the Columbia River in October and spawn from early November through December (Myers et al. 2006). Juvenile CR chum salmon migrate to the estuary as fry between February and May.

The WLCTRT identified 16 historical populations in 3 major population groups as shown in Table 3-17 (Myers et al. 2006).

Table 3-17 Historical populations in the CR chum ESU (Myers et al. 2006).

Stratum	Population*
Coastal	Grays (C,G), Elochoman (C), Mill Creek, Youngs Bay (C), Big Creek (C), Clatskanie, Scappoose
Cascade	Cowlitz (C, G?), Kalama, Lewis (C), Salmon Creek, Washougal, Clackamas (C), Sandy
Gorge	Lower Gorge (C,G), Upper Gorge

*The designations “C” and “G” identify Core and Genetic Legacy populations, respectively. Core populations historically represented the centers of abundance and productivity for a major population group. Genetic legacy populations have had minimal influence from nonendemic fish due to artificial propagation activities or exhibit important life history characteristics no longer found throughout the ESU (WLCTRT 2003).

3.2.3.4.1 Current Viability

Estimates of abundance and trends are available only for the Grays River and Lower Gorge populations. The 10-year trend was negative for the Grays River population and just over 1.0 for the Lower Gorge. These populations then increased for a few years before declining (Keller 2006).

Extinction risk over a 100-year time frame (Table 3-18) was derived qualitatively for each population, based on risk categories and criteria identified by the WLCTRT (WLCTRT 2004). Assessments were updated in 2007 for populations that spawn in Oregon tributaries (McElhany et al. 2007). The TRT’s rating system categorized extinction risk probabilities as very low, low, moderate, high, and very high based on abundance, productivity, spatial structure, and diversity characteristics. The risk assessment was based on a qualitative analysis of the best available data and anecdotal information for each population.

Table 3-18 Risk of extinction in 100 years; categories for populations of Columbia River chum (sources: Washington’s Lower Columbia Fish Recovery Board plan [LCFRB 2004] and McElhany et al. [2007] for Oregon populations).

Stratum	Population	State	Extinction Risk Category
Coastal	Grays	W	High
	Elochoman	W	High
	Mill Creek	W	Very High
	Youngs Bay	O	Very High
	Big Creek	O	Very High
	Clatskanie	O	Very High
	Scappoose	O	Very High
Cascade	Cowlitz	W	Very High
	Kalama	W	Very High

Stratum	Population	State	Extinction Risk Category
	Lewis	W	Very High
	Salmon	W	Very High
	Washougal	W	High
	Clackamas	O	Very High
	Sandy	O	Very High
Gorge	Lower Gorge	O/W	Very High/Moderate
	Upper Gorge	O/W	Very High/Very High

3.2.3.4.2 Limiting Factors

Limiting factors for this ESU are summarized below. For additional information, see the Washington Lower Columbia Recovery and Subbasin Plan (LCFRB 2004). (Oregon is currently developing a recovery plan for LCR chum salmon that spawn in Oregon tributaries.)

3.2.3.4.3 Tributary Habitat

Widespread development and land use activities have severely degraded stream habitats, water quality, and watershed processes affecting anadromous salmonids in most lower Columbia River subbasins, particularly in the low to moderate elevation habitats most often used by chum (NMFS 2008a).

3.2.3.4.4 Estuary Habitat

The estuary is an important habitat for migrating juveniles from Columbia River chum populations. Alterations in attributes of flow and diking have resulted in the loss of emergent marsh, tidal swamp and forested wetlands. These habitats are used extensively by chum juveniles, which migrate from their natal areas soon after emergence (Fresh et al. 2005). Estuary limiting factors and recovery actions are addressed in detail in a comprehensive regional planning process (NMFS 2007c).

3.2.3.4.5 Multipurpose Dams

FCRPS impacts on populations originating below the Portland/Vancouver metro area are limited to effects on migration and habitat conditions in the lower Columbia River below Bonneville and the estuary. Populations spawning above and just below Bonneville Dam are affected by passage, inundation of historic habitat, and flow management.

3.2.3.4.6 Harvest

Harvest impacts on chum are limited to indirect fishery mortality; there are currently no commercial or recreational fisheries on chum salmon. A small number of chum salmon (less than 50 fish in each of the last five years) are taken incidentally in lower river commercial gill net fisheries (NMFS 2008a).

3.2.3.4.7 Hatchery Practices

Historical hatchery practices do not appear to have influenced chum populations. WDFW's conservation hatcheries are currently an element of chum salmon protection and restoration efforts (NMFS 2008a).

3.2.3.4.8 Predation

Avian predators are assumed to have minimal effect on chum salmon. The significance of fish predation on juvenile chum and pinniped predation on adults is unknown (NMFS 2008a).

3.2.3.4.9 Ocean & Climate

Analyses of lower Columbia River salmon and steelhead status generally assumed that future ocean and climate conditions will approximate the average conditions that prevailed during the recent base period used for status assessments. However, until recently, conditions have been poor for most Columbia River salmonids than the long-term average and future trends are unclear. Further reductions in salmon production due to long-term ocean and climate trends will need to be addressed through implementation of additional recovery actions (NMFS 2008a).

3.2.4 Interior Columbia River ESU/DPSs

Middle Columbia River steelhead, Snake River (SR) spring/summer Chinook salmon, SR fall Chinook salmon, SR sockeye salmon, SR steelhead, Upper Columbia River (UCR) spring Chinook salmon, and UCR steelhead spawn in tributaries to the Columbia River above the mouth of the Willamette River (NMFS 2005c, NMFS 2006b). Adults and juveniles of these ESUs migrate through the lower Columbia River, and some juvenile rearing occurs there as well, as well as in the lower Willamette River below Willamette Falls.

3.2.4.1 Middle Columbia River Steelhead

The Middle Columbia River (MCR) steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams from above the Wind River, Washington, and the Hood River, Oregon (exclusive), upstream to, and including, the Yakima River, Washington, excluding *O. mykiss* from the Snake River Basin, as well seven artificial propagation programs (NMFS 2006b).

The Interior Columbia Technical Recovery Team (IC TRT) identified 17 extant populations of MCR steelhead in four major population groups (MPGs) (NMFS 2008a).

During the most recent 10-year period for which trends could be estimated, the trend in abundance was greater than 1.0 for three populations, stable for three populations, and less than 1.0 for the remainder (if this number is greater than 1.0, the population abundance is increasing; if it is less than 1.0, the abundance is decreasing). The risk presented to the MCR steelhead populations as a result of their spatial distribution is very low to moderate for all the populations except the Upper Yakima, where most historical spawning areas are not occupied. The risk presented by the status of genetic diversity is low to moderate for all but one MCR steelhead population. The Upper Yakima population has a high diversity risk due to introgression with resident *O. mykiss* and loss of juvenile life history variation as a result of habitat changes (NMFS 2008a).

Key limiting factors for the MCR steelhead DPS include multipurpose dams, tributary habitat and in-basin hydropower, water storage projects, predation, hatchery effects, harvest, and estuary conditions. Ocean conditions have also affected the status of this DPS (NMFS 2008a).

3.2.4.2 Snake River Fall Chinook

The Snake River (SR) Fall Chinook ESU includes all naturally spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River, as well as four artificial propagation programs (NMFS 2005c).

The IC TRT identified three historical populations of this ESU, although only the lower Snake River mainstem population is extant. This population extends from Hells Canyon to the confluence of the Snake and Columbia Rivers, including the lower reaches of tributaries to the Snake River (ICTRT 2003; McClure et al. 2005).

Total returns of fall Chinook over Lower Granite Dam increased steadily from the mid-1990s to the present. Over the last 23 full brood year returns through 2004, when only natural production is considered, SR fall Chinook populations have not replaced themselves (i.e., average R/S has been less than 1.0). However, R/S productivity was above 1.0 between 1995 and 1999, and preliminary estimates for the 2000-2003 brood years also indicate R/S>1.0 (NMFS 2008a).

The risk to the ESU as a result of its spatial distribution is moderately high because approximately 85% of historic habitat is inaccessible. Risk due to diversity for the ESU is moderately high because of the loss of diversity associated with extinct populations and the significant hatchery influence on the extant population (NMFS 2008a).

Key limiting factors for the SR fall Chinook salmon ESU include mainstem hydroelectric dams in the Columbia and Snake rivers, predation, harvest, hatcheries, the estuary, and tributary habitat. Ocean conditions have also affected the status of this ESU (NMFS 2008a).

3.2.4.3 Snake River Spring/Summer Chinook

The SR Spring/Summer Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as fifteen artificial propagation programs (NMFS 2005c).

The IC TRT identified 28 extant historical populations of SR spring/summer Chinook salmon and aggregated those populations into 5 major population groups (MPGs). Abundance has been stable or increasing for most SR spring/summer Chinook. 2007 SR spring Chinook jack counts, which are a qualitative indicator of future adult returns, were the second highest on record. However, SR spring/summer Chinook populations have not replaced themselves when only natural production is considered (i.e., average recruits per spawner has been less than 1.0). The risk posed to all SR spring/summer Chinook populations as a result of their spatial structure is low or moderate, except for the Upper Grande Ronde and Lemhi populations, which are at high risk for spatial structure. The risk posed by diversity factors to nearly all SR spring/summer Chinook populations is low or moderate, with the exception of some populations in the Upper Salmon MPG (NMFS 2008a).

Key limiting factors for the SR spring/summer Chinook salmon ESU include Federal and non-Federal multipurpose dams, predation, harvest, estuary conditions, and tributary habitat. Ocean conditions have also affected that status of this ESU. Although hatchery management is not identified as a limiting factor for the ESU as a whole, the ICTRT has indicated potential hatchery impacts for a few individual populations (NMFS 2008a).

3.2.4.4 Snake River Sockeye

The SR sockeye ESU includes all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive broodstock program (NMFS 2005c).

Although sockeye salmon were numerous in many areas of the Snake River basin, only a single remnant population, residing in the lakes of the Sawtooth Valley, Idaho, remains. From 1988 through 1999, the number of sockeye observed returning to Redfish Lake varied from 0 to 8 fish, with only three years when more than 1 fish returned. Since then, most of the returning fish have been of hatchery origin, although some residual sockeye have produced some adult returns. The highest number of adult returning in recent years was 257 in 2000. An average of about 12 fish per year have returned over the past 5 years. In addition, a substantial number of juvenile and adult fish of hatchery origin from this ESU are present in captive rearing facilities as part of an artificial propagation program. The program has been successful in its goals of preserving important lineages of Redfish Lake sockeye salmon for genetic variability and in preventing extinction in the near-term. The Stanley Basin Sockeye Technical Oversight Committee has determined that the next step toward meeting the goal of re-establishing and amplifying the wild population is to increase the number of smolts released.

The major factors limiting the conservation value of critical habitat for SR sockeye are the effects on the migration corridor posed by the mainstem lower Snake and Columbia River hydropower system, reduced tributary stream flows and high temperatures, and barriers to tributary migration. The spawning and rearing lakes lie within designated wilderness where habitat is considered good to excellent. Ocean conditions have also affected that status of this ESU (NMFS 2008a).

3.2.4.5 Snake River Steelhead

The SR steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, as well six artificial propagation programs (NMFS 2006b).

The IC TRT identified 24 populations in five major population groups. SR steelhead are also distinguished as A-run or B-run based on differences in migration timing and age and size at return. A-run steelhead are believed to occur throughout the steelhead streams in the Snake River Basin, and B-run are thought to be produced only in the Clearwater and Salmon rivers. Abundance has been stable or increasing for most A-run SR steelhead but declining for B-run SR steelhead during the last 20 brood cycles. Median population growth rate (lambda) was not available for average A-and B-run populations, but was positive for the two Grande Ronde populations with sufficient data to make an estimate. On average, during the last 20 full brood cycles, when only natural production is considered, A-run SR steelhead populations have replaced themselves (i.e., average R/S has been >1.0), while B-run steelhead have not. The risk posed to nearly all SR steelhead populations as a result of their spatial structure is very low or low. Only one population, Panther Creek, is categorized as having high risk as a result of its spatial structure, because only 30% of its historic range is occupied. The risk to all SR steelhead populations as a result of genetic diversity factors is low or moderate (NMFS 2008a).

Key limiting factors for the SR steelhead DPS include multipurpose dams, predation, harvest, hatchery effects, and tributary habitat. Ocean conditions have also affected the status of this DPS (NMFS 2008a).

3.2.4.6 Upper Columbia Spring Chinook

Upper Columbia River (UCR) spring Chinook spawn and rear in the mainstem Columbia River and its tributaries between Rock Island and Chief Joseph dams (NMFS 2008a).

This ESU contains one MPG composed of three existing populations and one extinct population. The upriver migration of this ESU is blocked by Chief Joseph Dam, completed in 1961. Prior to that, migration was blocked by Grand Coulee Dam, completed 20 years earlier (NMFS 2008a).

Based on Biological Review Team (BRT) trend estimates, abundance has declined for all three populations during the last 20 brood cycles. Population growth rate (lambda) is increasing for the Wenatchee and Methow populations and decreasing for the Entiat population. In 2007, UCR spring Chinook jack counts, an indicator of future adult returns, were at their highest level since 1977. The risk posed to all UCR spring Chinook populations as a result of spatial structure is either low or moderate, and risk posed by diversity factors is high, as a result of reduced genetic diversity from homogenization of populations (NMFS 2008a).

Key limiting factors for the UCR spring Chinook ESU include the FCRPS and Mid-Columbia multipurpose dams, predation, harvest, hatchery effects, and estuary and tributary habitats. Further consideration must take into account poor ocean conditions and the impact of hatchery practices (NMFS 2008a).

3.2.4.7 Upper Columbia River Steelhead

The Upper Columbia River (UCR) steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well six artificial propagation programs (NMFS 2006b).

The DPS consists of four populations in one major population group. Total abundance has been increasing for all UCR steelhead during the last 20 brood year returns, based on lambda and BRT trend estimates. When only natural production is considered, however, UCR steelhead populations have not been replacing themselves over the last 20 full brood year returns (i.e., average R/S has been less than 1.0). The risk posed to UCR steelhead populations by spatial structure is low for the Wenatchee and Methow, moderate for the Entiat, and high for the Okanogan. Risk to all UCR steelhead populations as a result of diversity factors is high, due to hatchery practices (NMFS 2008a).

Key limiting factors for the UCR steelhead DPS include multipurpose dams, predation, harvest (until the late 1980s), hatchery effects (until the late 1990s), and tributary and estuary habitat. Ocean conditions have also affected the status of this DPS (NMFS 2008a).

3.3 Critical Habitat for Columbia & Willamette Basin Salmonids

NMFS has designated critical habitat for 12 of the 13 salmon and steelhead species that may be affected by the Proposed Action.[4] Designated areas in the Willamette basin are most directly affected by the Proposed Action and as such, are given more detailed review. Critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line.[5] Within these areas, the primary constituent elements (PCEs) essential for the conservation of these species are those sites and habitat components that support one or more life stages, including:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival
- Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.
- Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation (NMFS 2005d) (offshore marine

[4] Critical habitat has not been designated for Lower Columbia River coho salmon.
[5] In areas where ordinary high-water line has not been defined, the lateral extent is the bankfull elevation (i.e., the level at which water begins to leave the channel and move into the floodplain, generally reached at a discharge with a 1- to 2-year recurrence interval).

PCEs were not identified for SR spring/summer Chinook salmon, SR fall Chinook salmon, and SR sockeye salmon; NMFS 1993 and 1999c).

NMFS describes the conservation role that the designated critical habitat provides each species below. The Critical Habitat Analytical Review Teams (CHARTs) rated 525 occupied fifth field hydrologic units (referred to as HUC5s or watersheds) in the Columbia River basin. The CHARTs gave each of these occupied watersheds a high, moderate, or low rating. High-value watersheds/areas are those with a high likelihood of promoting conservation, while low value watersheds/areas are expected to contribute relatively little. Conservation value was determined by considering the factors listed in Table 3-20.

Table 3-20 Factors considered by Columbia Basin CHARTs to determine the conservation value of occupied watersheds.

FACTORS	CONSIDERATIONS
PCE quantity	Total stream area or number of reaches in the watershed where PCEs are found; compares to both distribution in other watersheds and to probable historical quantity within the watershed
PCE quality – current condition	Existing condition of the quality of PCEs in the watershed
PCE quality – potential condition	Likelihood of achieving PCE potential in the watershed, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility
PCE quality – support of rarity/importance	Support of rare genetic or life history characteristics or rare/important types in the watershed
PCE quality – support of abundant populations	Support of variable-sized populations relative to other watersheds and the probably historical levels in the watershed
PCE quality – support of spawning/rearing	Support of spawning or rearing of varying numbers of populations (i.e., different run-timing or life history types within a single ESU and or different ESUs)

Of the 525 occupied watersheds, 382 were assigned a high rating, 93 a moderate rating, and 50 a low rating. The CHART ratings do not address SR spring/summer Chinook salmon, SR fall Chinook salmon, or SR sockeye salmon as critical habitat was designated for these ESUs in 1993. Ratings for the LCR coho salmon ESU are under development.

Many factors, both human-caused and natural, have contributed to the decline of salmon over the past century. Salmon habitat has been altered through activities such as urban development, logging, grazing, power generation, water storage projects, and agriculture. These habitat alterations have resulted in the loss of important spawning and rearing habitat and the loss or degradation of migration corridors (Table 3-21). NMFS describes the specific PCEs that were applied for each reach of designated critical habitat in the action area within the Environmental

Baseline chapter 4.0. In the Environmental Baseline chapter, existing habitat conditions are considered in terms of its ability to support the designated PCEs.

Table 3-21 Major factors limiting the conservation value of designated critical habitat for those species with designated critical habitat. (PCSRF 2006).

Species	Major Limiting Factors
UWR Chinook salmon	Reduced access to spawning/rearing habitat Degraded water quality High water temperature Lost/degraded floodplain connectivity and lowland stream habitat Reduced streamflow
UWR steelhead	Reduced access to spawning/rearing habitat Degraded water quality High water temperature Lost/degraded floodplain connectivity and lowland stream habitat Reduced streamflow
LCR Chinook salmon	Altered channel morphology and stability Reduced access to spawning/rearing habitat Loss of habitat diversity Excessive sediment High water temperature
LCR steelhead	Altered channel morphology and stability Lost/degraded floodplain connectivity and lowland stream habitat Reduced access to spawning/rearing habitat Excessive sediment High water temperature Reduced streamflow
CR chum salmon	Altered channel morphology and stability Excessive sediment Reduced streamflow Loss of habitat diversity
MCR steelhead	Altered channel morphology and floodplain Excessive sediment Impaired passage Degraded water quality Hydropower system mortality Reduced streamflow
SR spring/summer Chinook salmon	Altered channel morphology and floodplain Excessive sediment Degraded water quality Hydropower system mortality Reduced streamflow
SR fall Chinook salmon	Reduced spawning/rearing habitat Degraded water quality Hydropower system mortality
SR steelhead	Altered channel morphology and floodplain Excessive sediment Degraded water quality Hydropower system mortality Reduced streamflow

Species	Major Limiting Factors
SR sockeye salmon	Altered channel morphology and floodplain Impaired passage Reduced streamflow Hydropower system mortality
UCR spring Chinook salmon	Altered channel morphology and floodplain Riparian degradation and loss of in-river large woody debris Impaired passage Reduced streamflow Hydropower system mortality
UCR steelhead	Altered channel morphology and floodplain Riparian degradation and loss of in-river large woody debris Excessive sediment Degraded water quality Reduced streamflow Hydropower system mortality

3.3.1 Critical Habitat for Upper Willamette River (UWR) Chinook Salmon

3.3.1.1 McKenzie Subbasin

Figure 3-8 shows the designation of critical habitat for UWR Chinook salmon in the McKenzie subbasin and its respective watersheds.

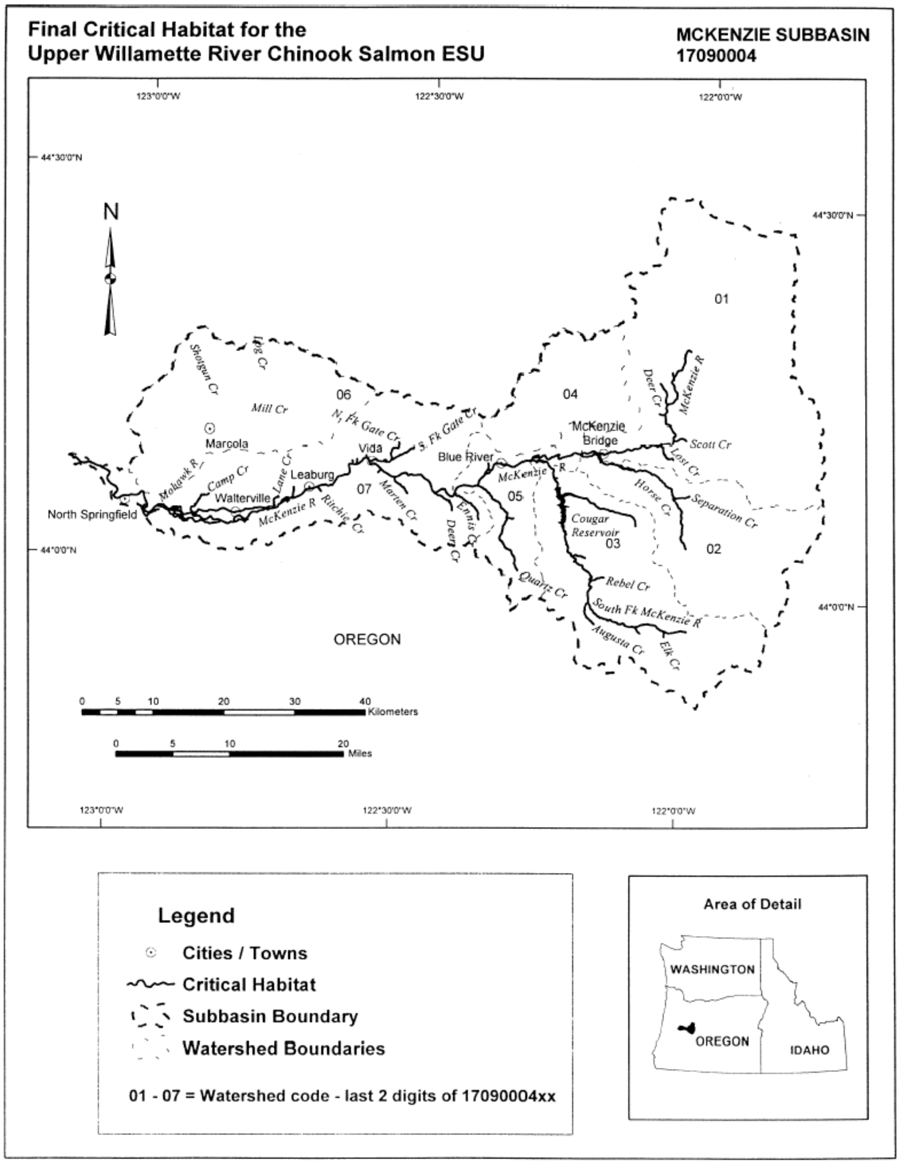

Figure 3-8 Critical habitat in the McKenzie subbasin

For UWR Chinook salmon, the CHART rated seven occupied watersheds found in the McKenzie subbasin. Each watershed is numbered in Figure 3-8, and represents individual watersheds. Of these seven watersheds, five were assigned a high rating and two a medium rating (NMFS 2005g). The watersheds that received a high rating include: Upper McKenzie River (1709000401), Horse Creek (1709000402), South Fork McKenzie River (1709000403), McKenzie River/Quartz Creek (1709000405), and Lower McKenzie River (1709000407). The watersheds that received a medium rating were Blue River (1709000404) and Mohawk River (1709000406) (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Blue River (1709000404) and Mohawk River (1709000406) watersheds because economic benefits of exclusion outweighed the benefits of designation. Among the mainstem McKenzie and many tributaries included in NMFS' final designation of critical habitat were the South Fork McKenzie River both above and below Cougar Dam (NMFS 2005d).

3.3.1.2 Middle Fork Willamette Subbasin

Figure 3-9 shows the designation of critical habitat for UWR Chinook salmon in the Middle Fork Willamette subbasin and its respective watersheds.

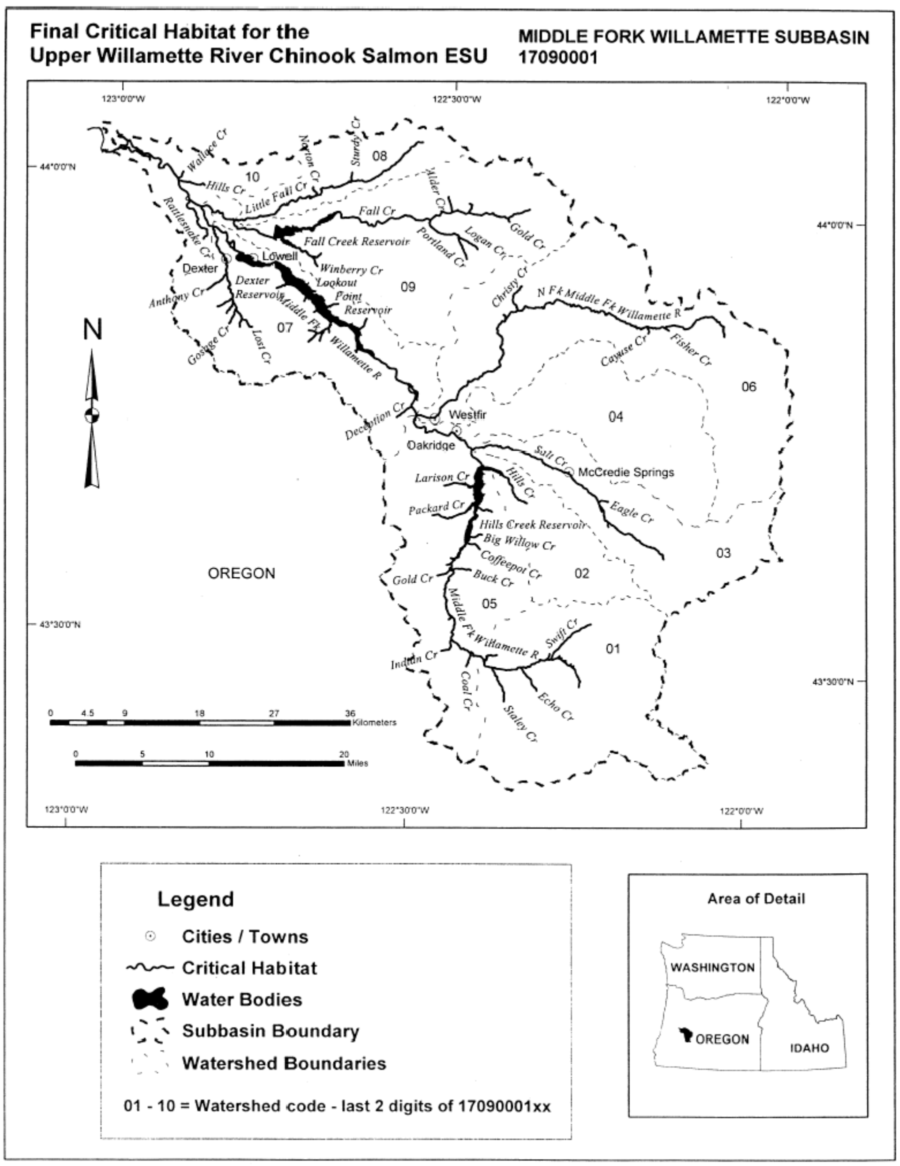

Figure 3-9 Critical habitat in the Middle Fork Willamette subbasin.

The CHART rated ten watersheds found in the Middle Fork Willamette subbasin; each has a number in Figure 3-9. Of the ten watersheds reviewed, four were rated as having high and six were rated as having medium conservation value. Watersheds that received a high rating include: Upper Middle Fork Willamette River watershed (1709000101), Salt Creek/Willamette River watershed (1709000103), North Fork of Middle Fork Willamette River watershed (1709000106), and Fall Creek watershed (1709000109). Those that received a medium rating include: Hills Creek watershed (1709000102), Salmon Creek watershed (1709000104), Hills Creek Reservoir watershed (1709000105), Middle Fork Willamette/Lookout Point watershed (1709000107), Little Fall Creek watershed (1709000108), and Lower Middle Fork of Willamette River watershed (1709000110) (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Salmon Creek watershed (1709000104) economic benefits of exclusion outweighed the benefits of designation. NMFS included the mainstem Middle Fork Willamette, including extensive mainstem reaches and tributaries above Dexter, Lookout Point, and Hills Creek dams. NMFS also included the North Fork Middle Fork Willamette and Salt Creek above Lookout Point dam, as well as Fall Creek and many tributaries above and below Fall Creek dam (NMFS 2005d).

3.3.1.3 Coast Fork Willamette Subbasin

The CHART rated four watersheds in the Coast Fork Willamette subbasin. Row River (1709000201), Mosby Creek (1709000202), Upper Coast Fork Willamette River (1709000203), and Lower Coast Fork Willamette River (1709000205) watersheds all received low ratings (NMFS 2005g).

The entire Coast Fork Willamette subbasin was excluded in NMFS' final determination of critical habitat.

3.3.1.4 Upper Willamette Subbasin

Figure 3-10 shows the designation of critical habitat for UWR Chinook salmon in the Upper Willamette River subbasin and its respective watersheds.

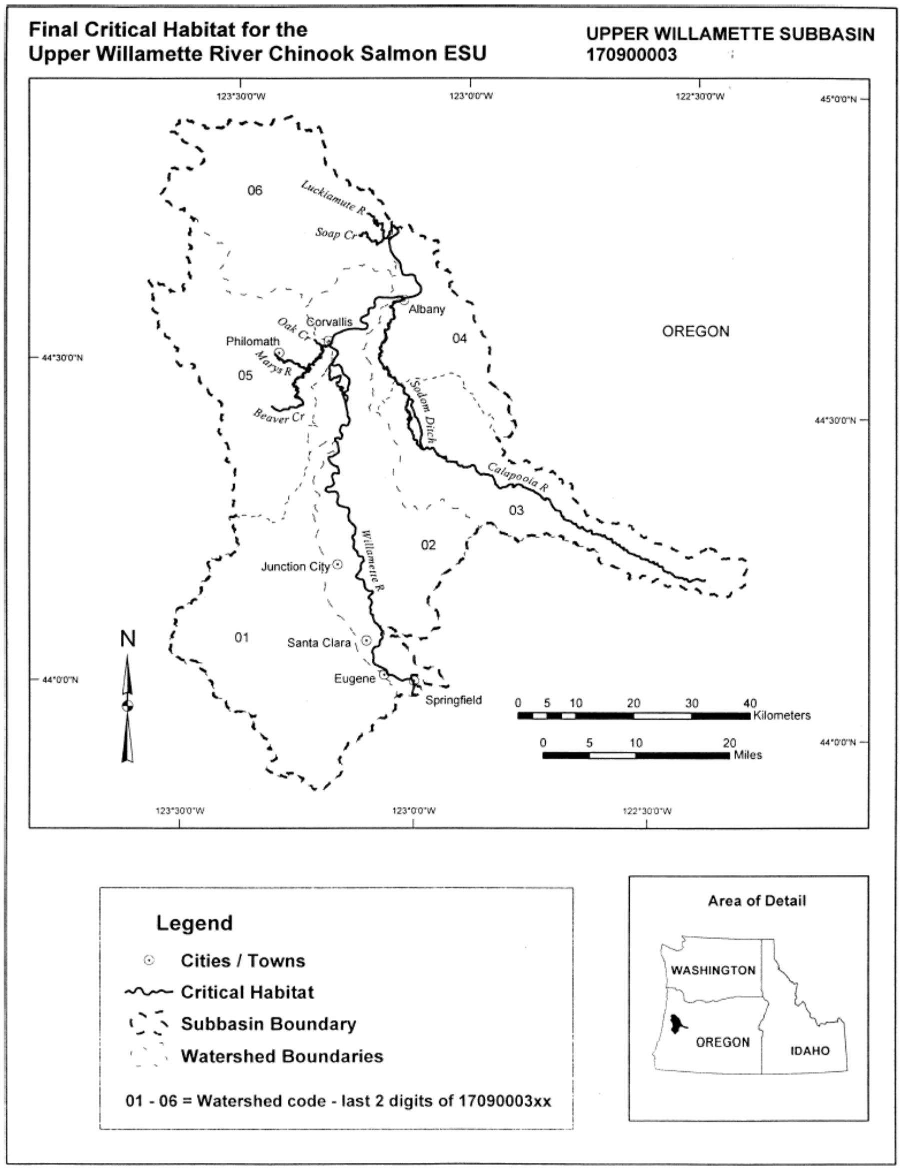

Figure 3-10 Critical habitat in the Upper Willamette subbasin.

The CHART rated six watersheds found in the Upper Willamette subbasin, numbered in Figure 3-10. Of the six watersheds reviewed, three were rated as having low and three were rated as having medium conservation value. Watersheds that received a medium rating include: Calapooia River watershed (1709000303), Marys River watershed (1709000305), and Luckiamute River watershed (1709000306). Those that received a low rating include: Long Tom River watershed (1709000301), Muddy Creek watershed (1709000302), and Oak Creek watershed (1709000304) (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Long Tom River watershed (1709000301) and the tributaries of the Muddy Creek (1709000302) and Oak Creek (170900304) watersheds because economic benefits of exclusion outweighed the benefits of designation. NMFS included the mainstem Willamette River, the Calapooia River, and portions of the Mary's River and Luckiamute River watersheds (NMFS 2005d).

3.3.1.5 North Santiam Subbasin

Figure 3-11 shows the designation of critical habitat for UWR Chinook salmon in the North Santiam subbasin and its respective watersheds.

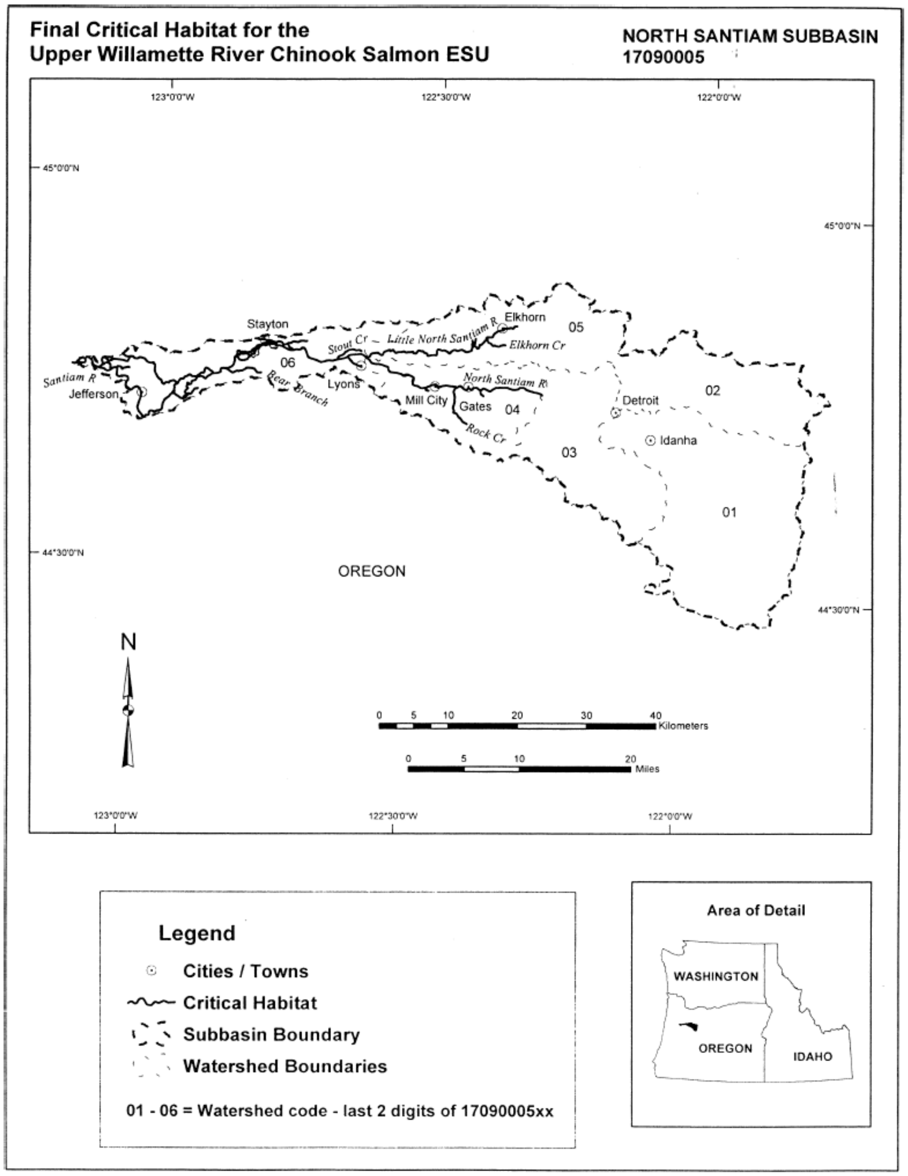

Figure 3-11 Critical habitat in the North Santiam subbasin.

The CHART rated three occupied watersheds found in the North Santiam subbasin, and numbered in Figure 3-11. The Middle North Santiam River watershed (1709000504) and Little North Santiam River watershed (1709000505) were rated as having a high conservation value and the Lower North Santiam watershed (1709000506) was rated as having a medium conservation value (NMFS 2005g).

The CHART also rated three unoccupied watersheds. The Upper North Santiam River watershed (1709000501) and North Fork Breitenbush River watershed (1709000502) were rated as possibly having high conservation value and the Detroit Reservoir/Blowout Divide Creek watershed (1709000503) was rated as possibly having medium conservation value (NMFS 2005g). The CHART concluded that the currently unoccupied watersheds may be essential to the conservation of the ESU.

In its final designation of critical habitat, NMFS excluded the three unoccupied watersheds because the economic benefits of exclusion outweighed the benefits of designation. Critical habitat includes the mainstem North Santiam below Big Cliff and Detroit dams, as well as portions of the Little North Fork Santiam River watershed (NMFS 2005d).

3.3.1.6 South Santiam Subbasin

Figure 3-12 shows the designation of critical habitat for UWR Chinook salmon in the South Santiam subbasin and its respective watersheds.

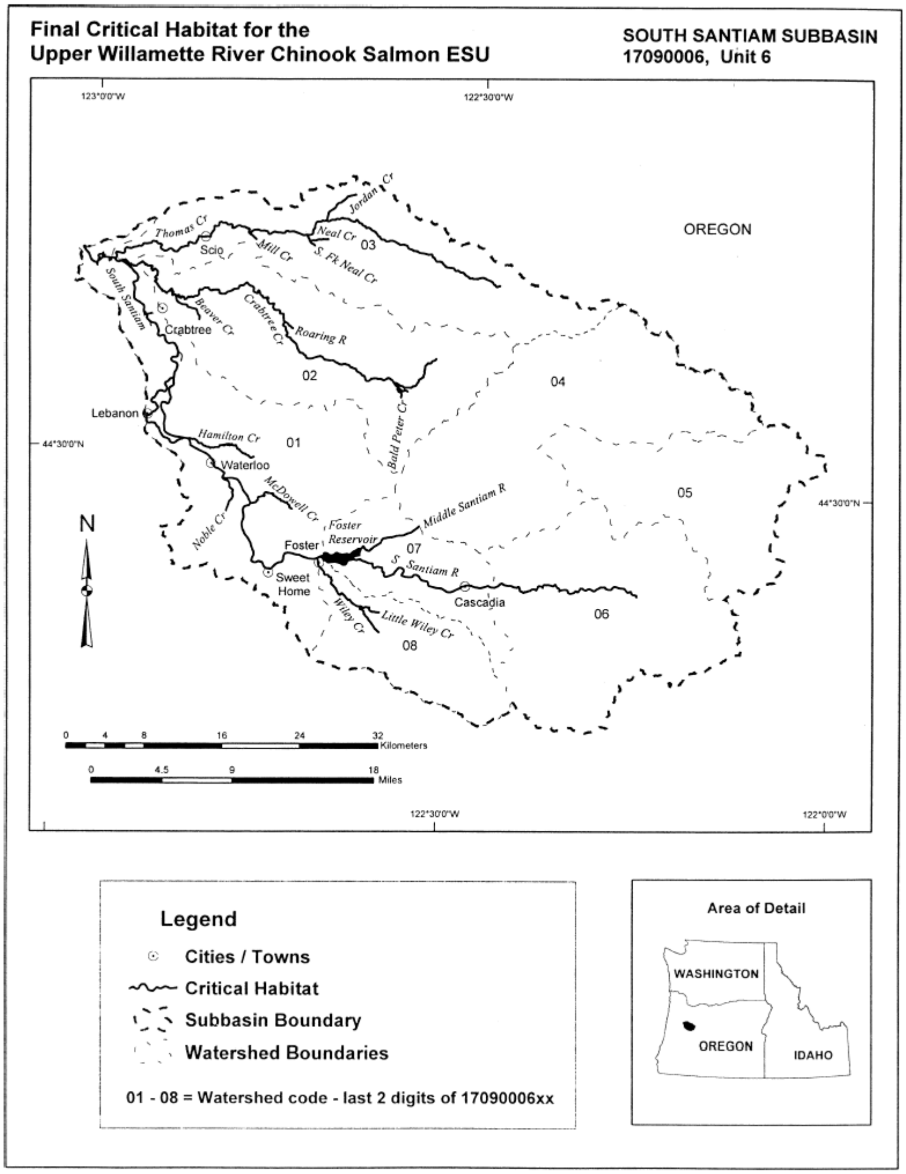

Figure 3-12 Critical habitat in the South Santiam subbasin.

The CHART rated six watersheds in the South Santiam subbasin, numbered in Figure 3-12. Of the six watersheds reviewed, three were rated as having high and three were rated as having medium conservation value. Those that received a high rating include: Hamilton Creek/South Santiam River watershed (1709000601), South Santiam River watershed (1709000606), and South Santiam River/Foster Reservoir watershed (1709000607). Those that received a medium rating include: Crabtree Creek watershed (1709000602), Thomas Creek watershed (1709000603), and Wiley Creek watershed (1709000608) (NMFS 2005g).

In its final designation of critical habitat, NMFS included the mainstem South Santiam both below and above Foster and Green Peter dams and portions of the Middle Santiam River (NMFS 2005d).

3.3.1.7 Middle Willamette Subbasin

Figure 3-13 shows the designation of critical habitat for UWR Chinook salmon in the Middle Willamette subbasin and its respective watersheds.

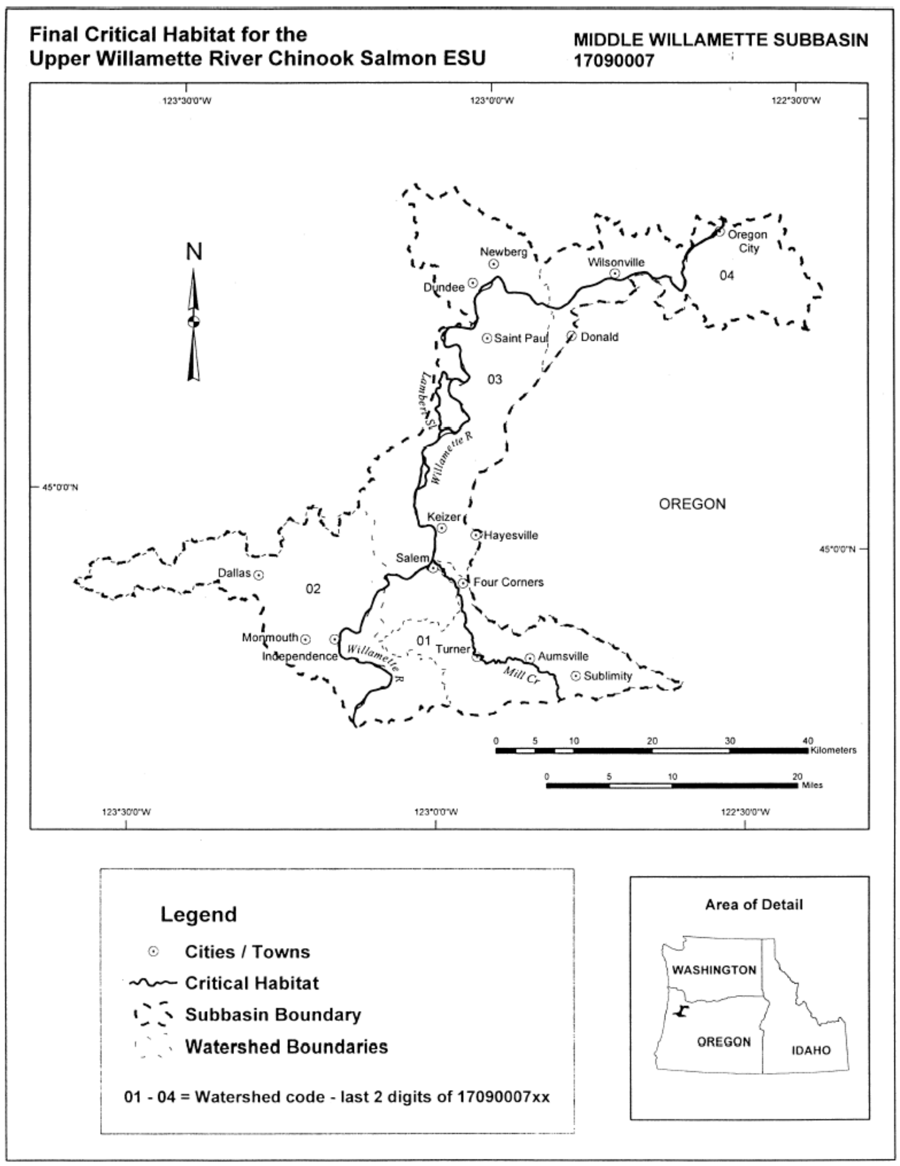

Figure 3-13 Critical habitat in the Middle Willamette subbasin.

The CHART rated four watersheds, numbered in Figure 3-13, in the Middle Willamette subbasin and concluded that all of the watersheds in this subbasin were of low conservation value. The watersheds include: Mill Creek/Willamette River Watershed (1709000701), Rickreall Creek watershed (1709000702), Willamette River/Chehalem Creek watershed (1709000703), and Abernethy Creek watershed (1709000704) (NMFS 2004g).

In its final designation of critical habitat, NMFS excluded the tributaries of all four watersheds. However, NMFS designated the mainstem Willamette River and portions of Mill Creek as critical habitat (NMFS 2005d).

3.3.1.8 Molalla/Pudding Subbasin

Figure 3-14 shows the designation of critical habitat for UWR Chinook salmon in the Molalla/Pudding subbasin and its respective watersheds.

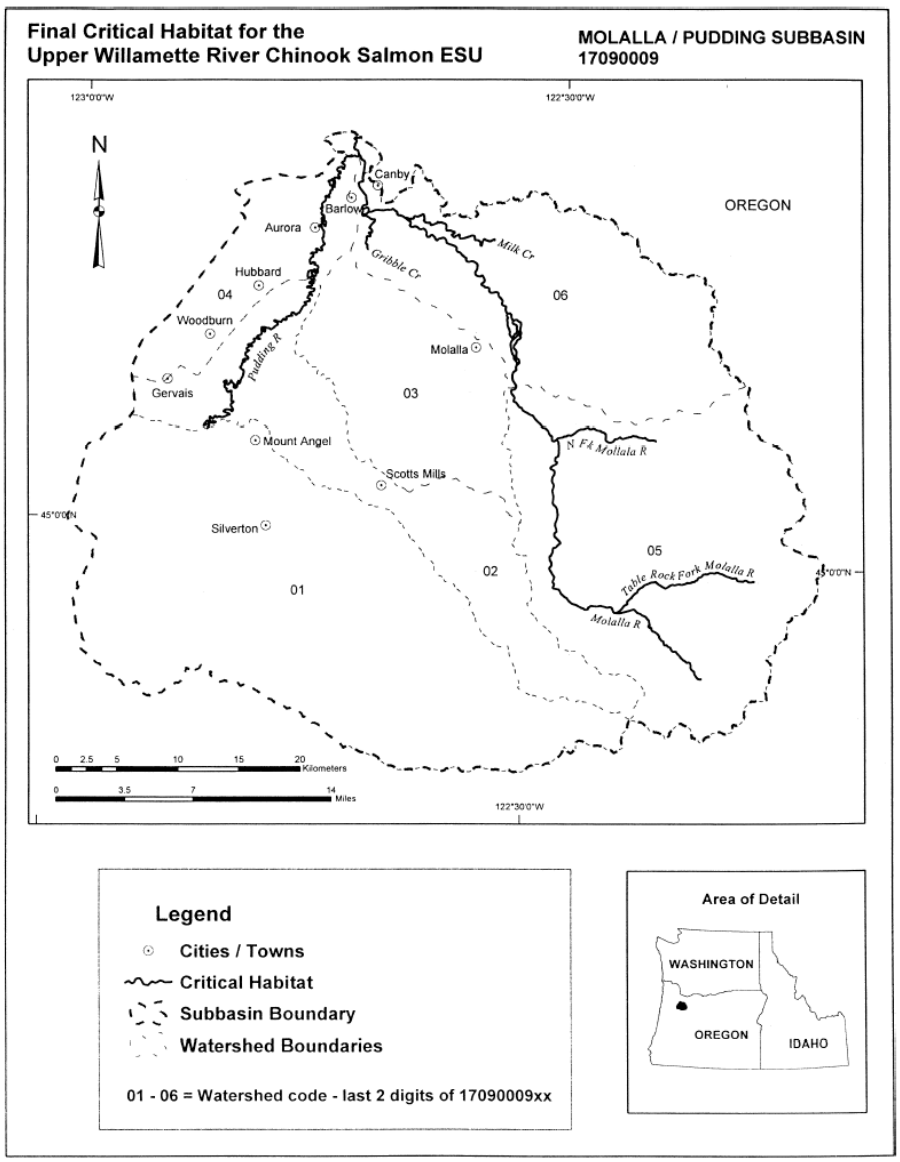

Figure 3-14 Critical habitat in the Molalla/Pudding subbasin.

The CHART rated six watersheds in the Molalla/Pudding subbasin, numbered in Figure 3-14. The Upper Molalla River watershed (1709000905) and Lower Molalla River watershed (1709000906) received a medium rating. The Abiqua Creek/Pudding River (1709000901), Butte Creek/Pudding River (1709000902), Rock Creek/Pudding River (1709000903), and Senecal Creek/Mill Creek watersheds (1709000904) received a low rating (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Abiqua Creek/Pudding River (1709000901) and Rock Creek/Pudding River (1709000903) watersheds and the tributaries of the Butte Creek/Pudding River (1709000902) and Senecal Creek/Mill Creek (1709000904) watersheds because the economic benefits of exclusion outweighed the benefits of designation. NMFS included the mainstem Pudding River as well as the mainstem Molalla River and several of its tributaries (NMFS 2005d).

3.3.1.9 Clackamas Subbasin

Figure 3-15 shows the designation of critical habitat for UWR Chinook salmon in the Clackamas subbasin and its respective watersheds.

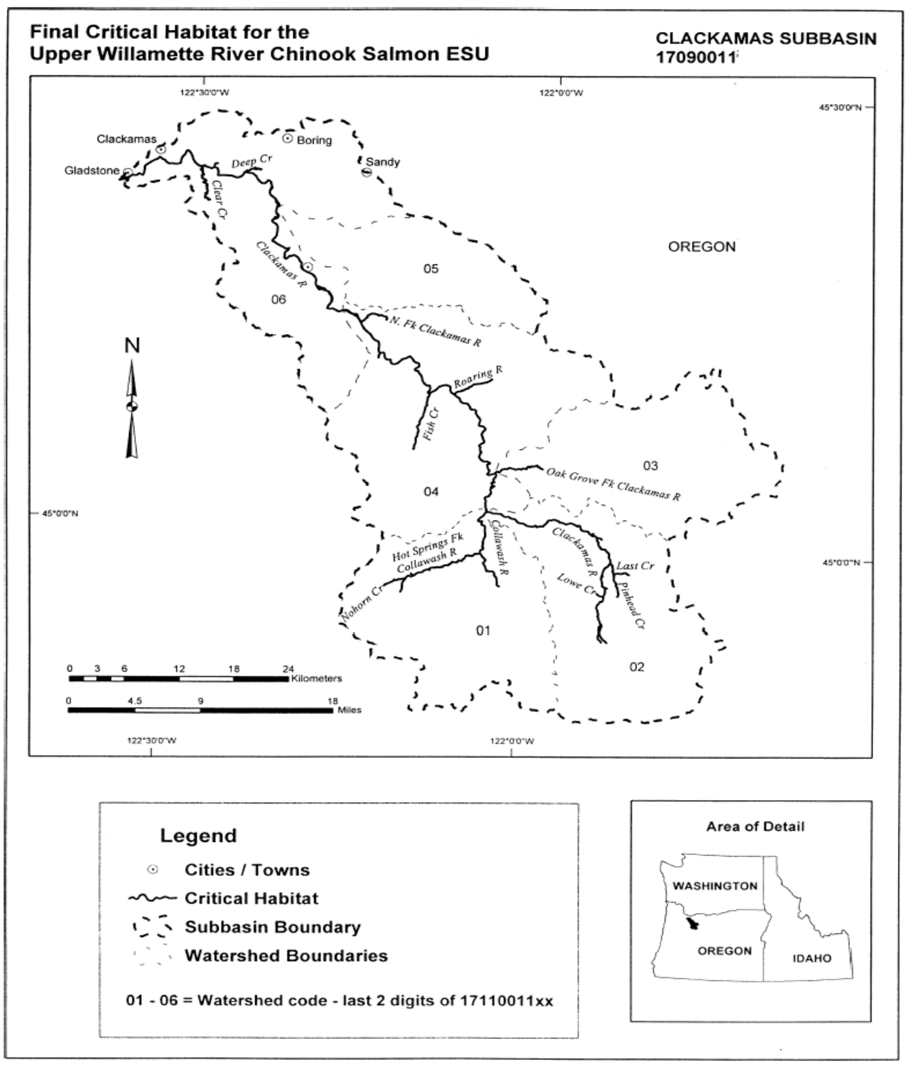

Figure 3-15 Critical habitat in the Clackamas subbasin.

The CHART rated six watersheds in the Clackamas subbasin, numbered in Figure 3-15. Of the six watersheds reviewed, five were rated as having high conservation value and one was rated as having low conservation value. Those that received a high rating include: Collawash River (1709001101), Upper Clackamas River (1709001102), Oak Grove Fork Clackamas River (1709001103), Middle Clackamas River (1709001104), and Lower Clackamas River watersheds (1709001106). The Eagle Creek watershed (1709001105) received a low rating (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Eagle Creek watershed (1709001105) because the economic benefits of exclusion outweighed the benefits of designation. NMFS included the Clackamas River, Roaring River, and Collawash River in its critical habitat designations (NMFS 2005d).

3.3.1.10 Lower Willamette/Columbia River Corridor

Figure 3-16 shows the designation of critical habitat for UWR Chinook salmon in the lower Willamette/Columbia River corridor.

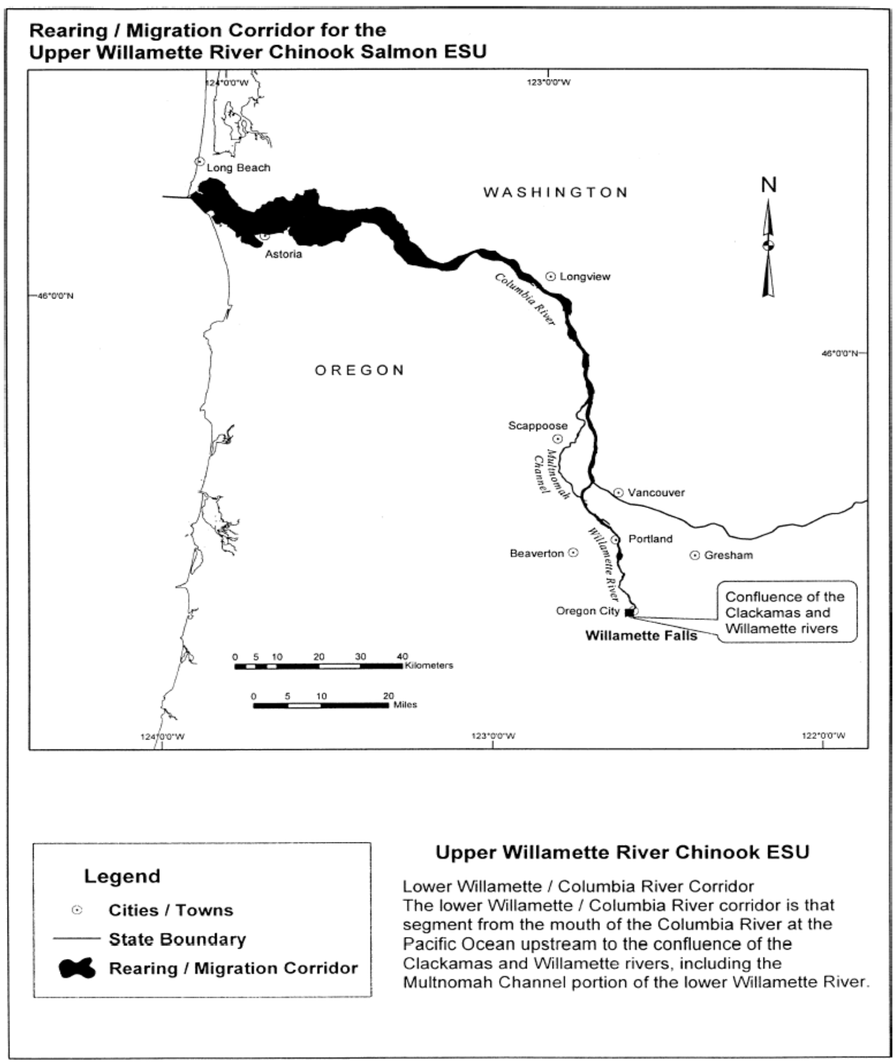

Figure 3-16 Critical habitat in the Lower Willamette/Columbia River corridor.

The CHART concluded that the Lower Willamette/Columbia River corridor was of high conservation value to the UWR Chinook ESU (NMFS 2005g).

In its final designation, NMFS included the entire corridor as critical habitat (NMFS 2005d).

3.3.2 Critical Habitat for Upper Willamette River (UWR) Steelhead

3.3.2.1 Upper Willamette Subbasin

Figure 3-17 shows the designation of critical habitat for UWR steelhead in the Upper Willamette subbasin and its respective watersheds.

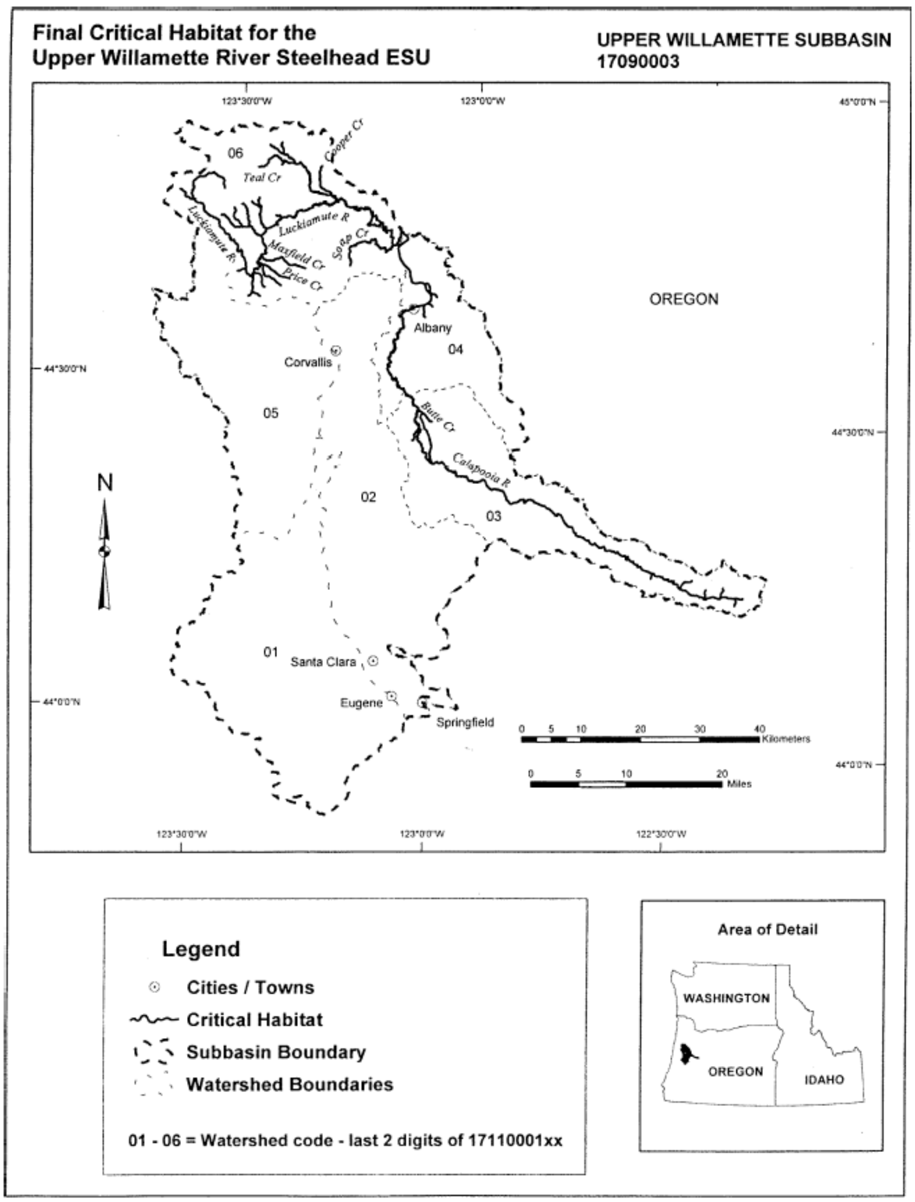

Figure 3-17 Critical habitat in the Upper Willamette subbasin.

The CHART rated three watersheds in the Upper Willamette subbasin, numbered in Figure 3-17, and concluded that one of the watersheds in this subbasin was of high and two were of medium conservation value to the ESU. The Calapooia River watershed (1709000303) received a high rating while the Oak Creek watershed (1709000304) and Luckiamute River watershed (1709000306) received medium ratings. The CHART also concluded that all reaches of the Willamette River within this subbasin constitute a high value rearing and migration corridor for the Calapooia River population of UWR steelhead (NMFS 2005g).

In its final designation of critical habitat, NMFS included the mainstem Calapooia River, the mainstem Luckiamute River, and portions of tributaries to those rivers (NMFS 2005d).

3.3.2.2 North Santiam Subbasin

Figure 3-18 shows the designation of critical habitat for UWR steelhead in the North Santiam subbasin and its respective watersheds.

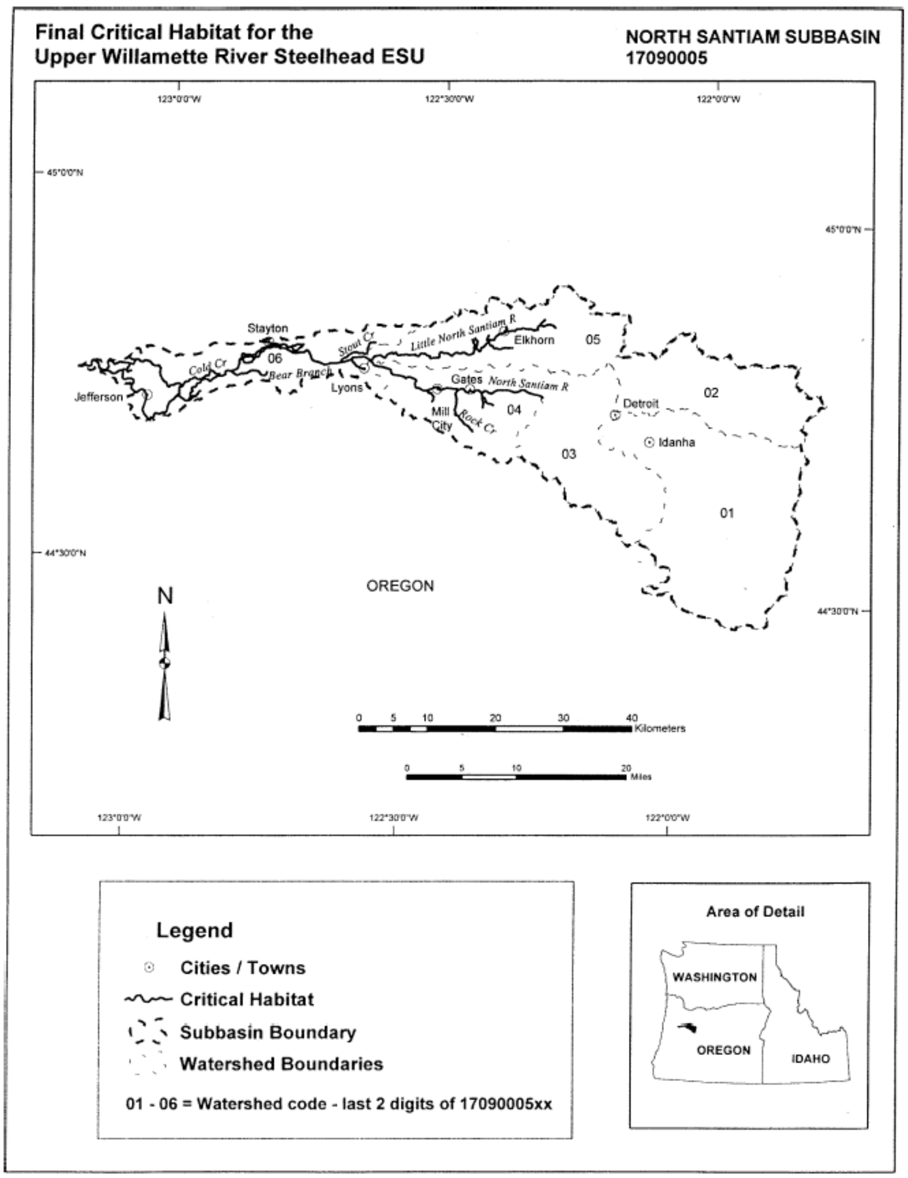

Figure 3-18 Critical habitat in the North Santiam subbasin.

The CHART rated three watersheds in the North Santiam subbasin, numbered in Figure 3-18, and concluded that all three were of high conservation value to the ESU. The Middle North Santiam River (1709000504), Little North Santiam River (1709000505), and Lower North Santiam River (1709000506) received a high rating (NMFS 2005g).

Critical habitat includes the mainstem North Santiam below Big Cliff and Detroit dams, and portions of the Little North Fork Santiam River watershed (NMFS 2005d).

3.3.2.3 South Santiam Subbasin

Figure 3-19 shows the designation of critical habitat for UWR steelhead in the South Santiam subbasin and its respective watersheds.

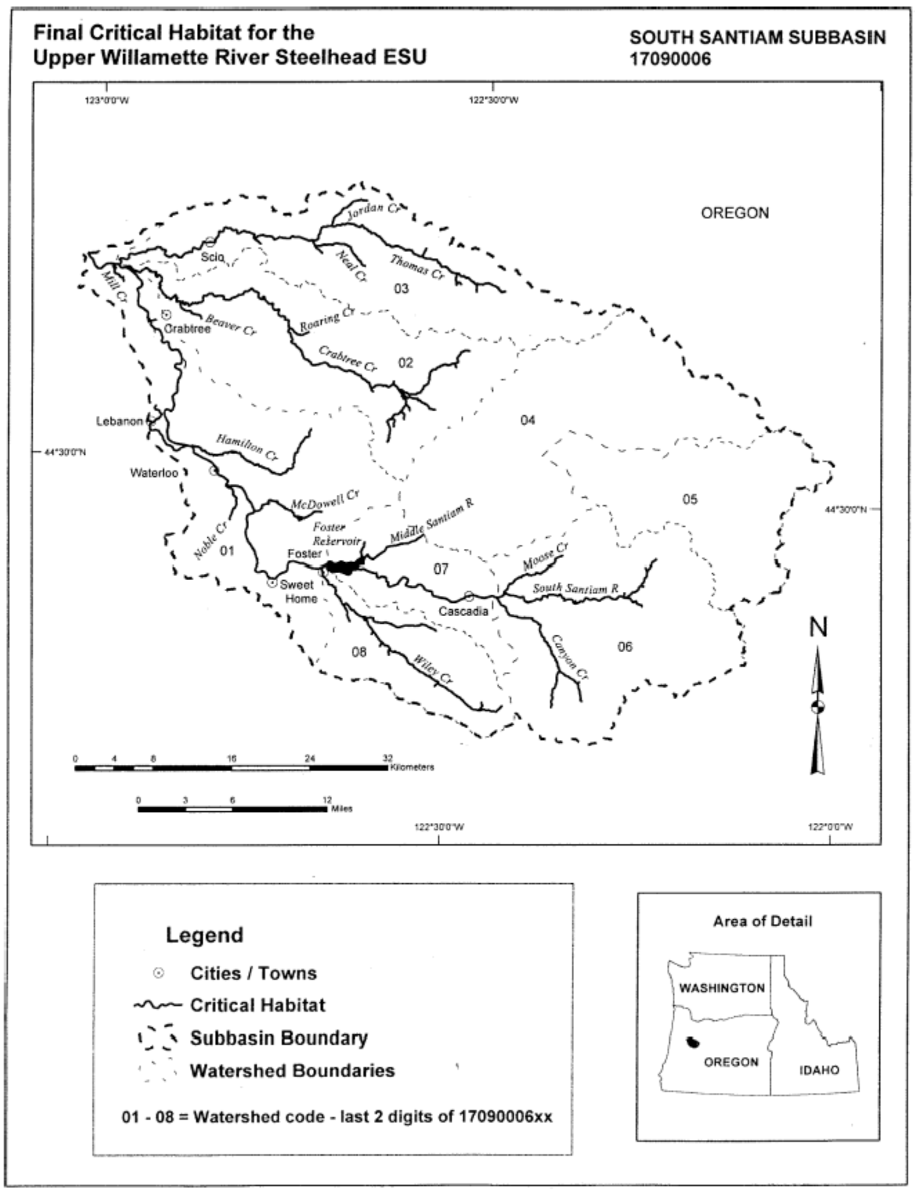

Figure 3-19 Critical habitat in the South Santiam subbasin.

The CHART rated six watersheds in the South Santiam subbasin, numbered in Figure 3-19, and concluded that all of them were of high conservation value to the ESU. The watersheds that received a high rating include: Hamilton Creek/South Santiam River watershed (1709000601), Crabtree Creek watershed (1709000602), Thomas Creek watershed (1709000603), South Santiam River watershed (1709000606), South Santiam River/Foster Reservoir watershed (1709000607), and Wiley Creek watershed (1709000608) (NMFS 2005g).

In its final designation of critical habitat, NMFS included the mainstem South Santiam both below and above Foster and Green Peter dams, including portions of the Middle Santiam River (NMFS 2005d).

3.3.2.4 Middle Fork Willamette Subbasin

Figure 3-20 shows the designation of critical habitat for UWR steelhead in the Middle Fork Willamette subbasin and its respective watersheds.

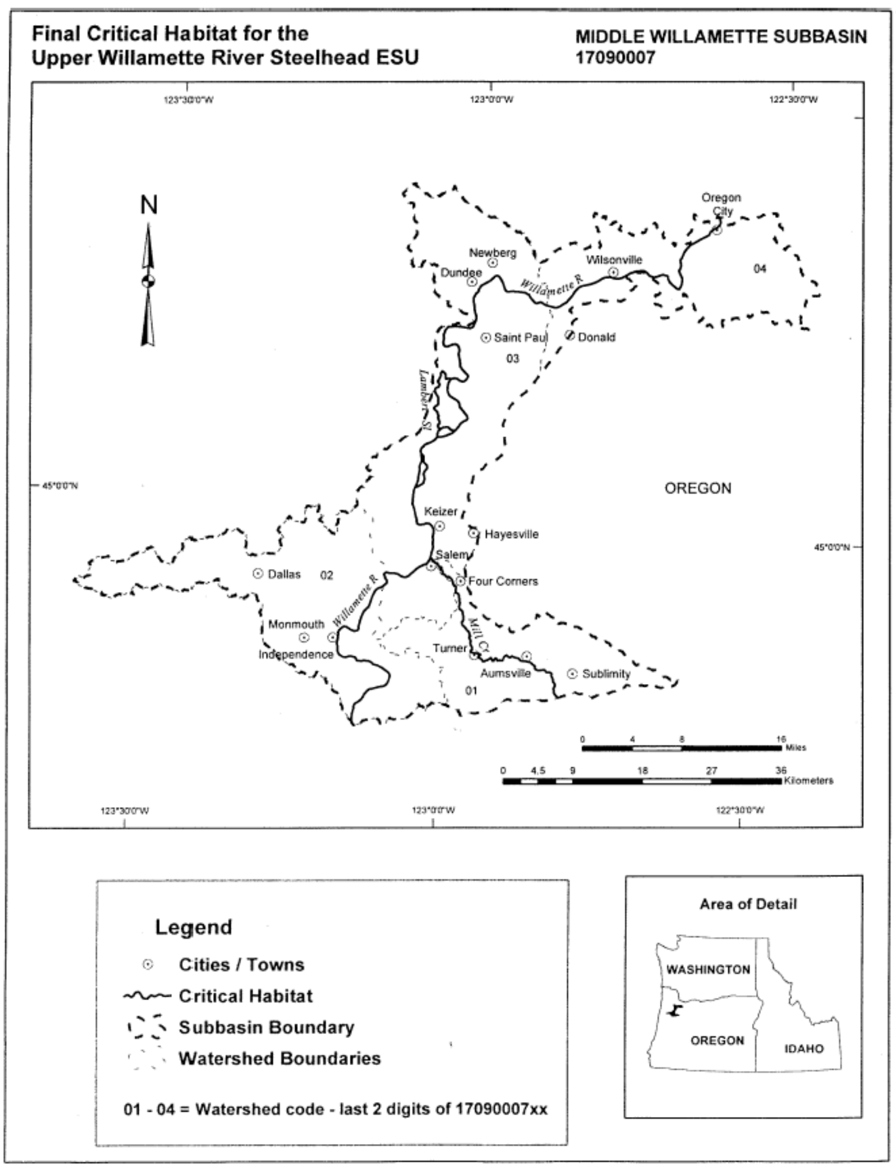

Figure 3-20 Critical habitat in the Middle Fork Willamette subbasin.

The CHART rated four watersheds in the Middle Willamette subbasin, numbered in Figure 3-20, and concluded that all four watersheds were of low conservation value to the ESU. However, that assessment pertained solely to the tributary streams in these watersheds, and not to the mainstem Willamette River or Mill Creek. The CHART concluded that all reaches of the Willamette River within this subbasin constitute a high value rearing and migration corridor. The four watersheds that received a low rating include: Mill Creek/Willamette River watershed (1709000701), Rickreall Creek watershed (1709000702), Willamette River/Chehalem Creek watershed (1709000703), and Abernethy Creek watershed (1709000704) (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the tributaries of all four watersheds because the economic benefits of exclusion outweighed the benefits of designation. However, NMFS designated the mainstem Willamette River and portions of Mill Creek as critical habitat (NMFS 2005d).

3.3.2.5 Yamhill Subbasin

Figure 3-21 shows the designation of critical habitat for UWR steelhead in the Yamhill subbasin and its respective watersheds.

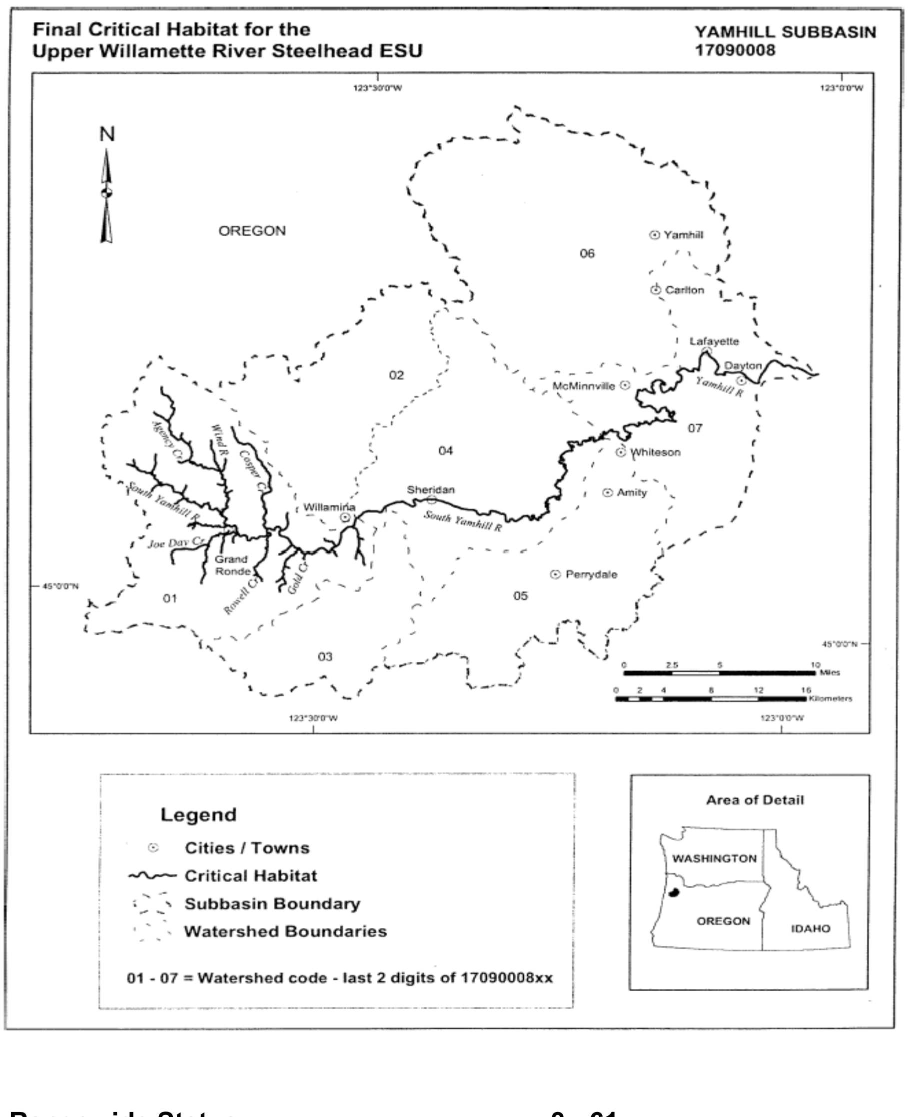

Figure 3-21 Critical habitat in the Yamhill subbasin.

The CHART rated seven watersheds in the Yamhill subbasin, numbered in Figure 3-21. Of the seven watersheds, one received a medium rating and six received a low rating. The Upper South Yamhill River watershed (1709000801) received a medium rating. The watersheds that received a low rating include: Willamina Creek watershed (1709000802), Mill Creek/South Yamhill River watershed (1709000803), Lower South Yamhill River watershed (1709000804), Salt Creek/South Yamhill River watershed (1709000805), North Yamhill River watershed (1709000806), and Yamhill River watershed (1709000807) (NMFS 2005g).

In its final designation of critical habitat, NMFS excluded the entire Willamina Creek, (1709000802), Mill Creek/South Yamhill River (1709000803), Salt Creek/South Yamhill River (1709000805), and North Yamhill River (1709000806) watersheds because the economic benefits of exclusion outweighed the benefits of designation. NMFS also excluded the tributaries from the Lower South Yamhill River (1709000804) and Yamhill River (1709000807) watersheds and Indian lands from the Upper South Yamhill River watershed (1709000801) because the economic benefits of exclusion outweighed the benefits of designation. NMFS designated the Yamhill River and South Yamhill River as critical habitat (NMFS 2005d).

3.3.2.6 Molalla/Pudding Subbasin

Figure 3-22 shows the designation of critical habitat for UWR steelhead in the Molalla/Pudding subbasin and its respective watersheds.

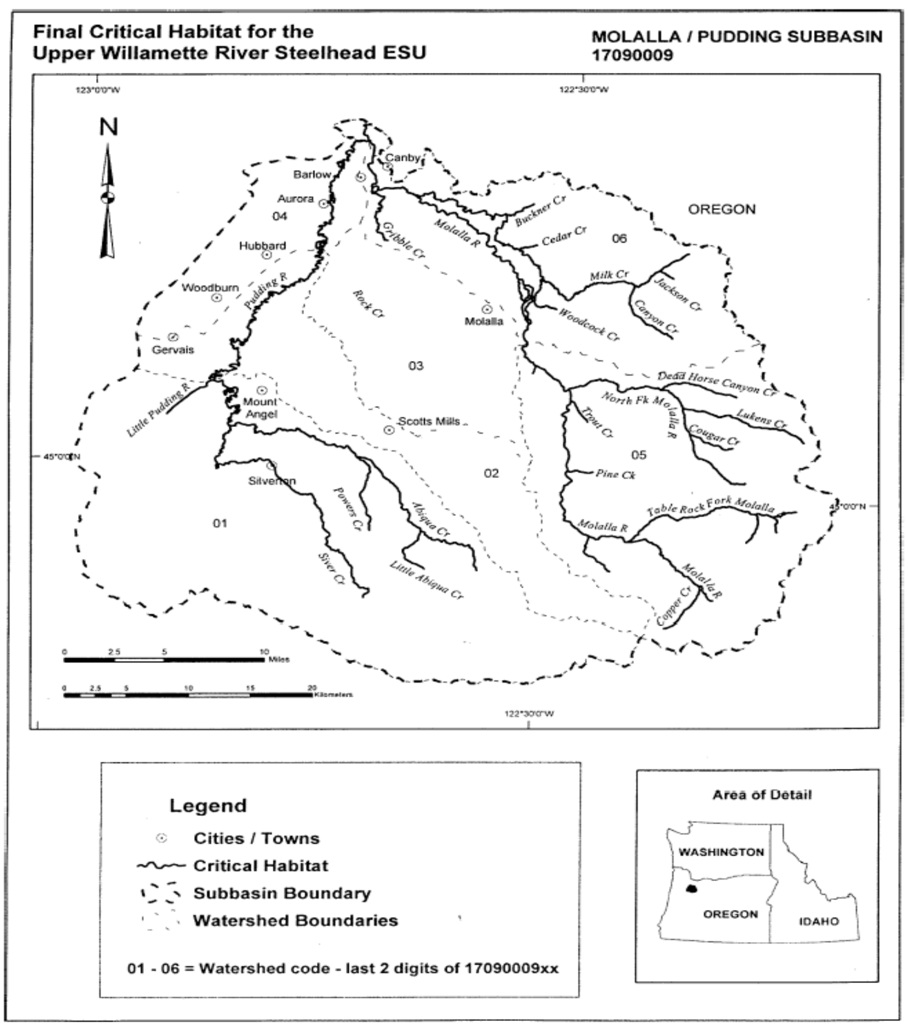

Figure 3-22 Critical habitat in the Molalla/Pudding subbasin.

The CHART rated six watersheds in the Molalla/Pudding subbasin, numbered in Figure 3-22. The Upper Molalla River watershed (1709000905) received a high rating. The Butte Creek/Pudding River (1709000902), Rock Creek/Pudding River (1709000903), and Lower Molalla River watersheds (1709000906) received a medium rating. The Abiqua Creek/Pudding River watershed (1709000901) and the Senecal Creek/Mill Creek watershed (1709000904) received a low rating (NMFS 2005g).

In its final critical habitat designation, NMFS excluded the entire Rock Creek/Pudding River (1709000903) watershed and the tributaries of the Butte Creek/Pudding River (1709000902) and Senecal Creek/Mill Creek (1709000904) watersheds because the economic benefits of exclusion outweighed the benefits of designation. NMFS included the Molalla River and the Pudding River as critical habitat (NMFS 2005d).

3.3.2.7 Tualatin Subbasin

Figure 3-23 shows the designation of critical habitat for UWR steelhead in the Tualatin subbasin and its respective watersheds.

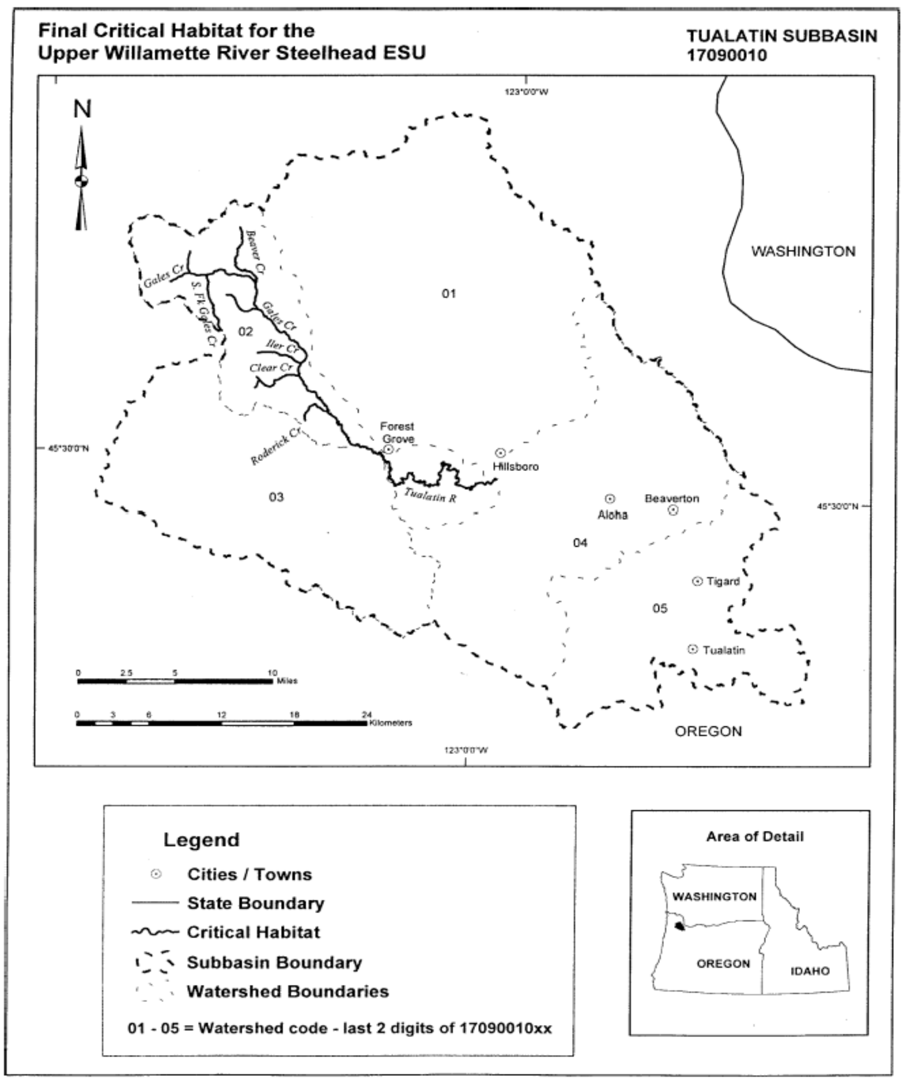

Figure 3-23 Critical habitat in the Tualatin subbasin.

The CHART rated five watersheds in the Tualatin subbasin, numbered in Figure 3-23, and concluded that the Gales Creek watershed may have the highest potential conservation benefit in the subbasin. The Gales Creek watershed (1709001002) received a medium rating while habitat areas in the remaining four watersheds received a low rating. Those watersheds that received a low rating include: Dairy Creek watershed (1709001001), Scoggins Creek watershed (1709001003), Rock Creek/Tualatin River watershed (1709001004), and Lower Tualatin River watershed (1709001005) (NMFS 2005g).

In its final critical habitat designation, NMFS excluded four entire watersheds because the economic benefits of exclusion outweighed the benefits or designation. Those excluded were as follows: Dairy Creek watershed (1709001001), Scoggins Creek watershed (1709001003), Rock Creek/Tualatin River watershed (1709001004), and Lower Tualatin River watershed (1709001005). NMFS included the mainstem Tualatin River in the Gales Creek watershed as well as Gales Creek and many of its tributaries (NMFS 2005d).

3.3.2.8 Lower Willamette/Columbia River Corridor

Figure 3-24 shows the designation of critical habitat for UWR steelhead in the lower Willamette/Columbia River corridor.

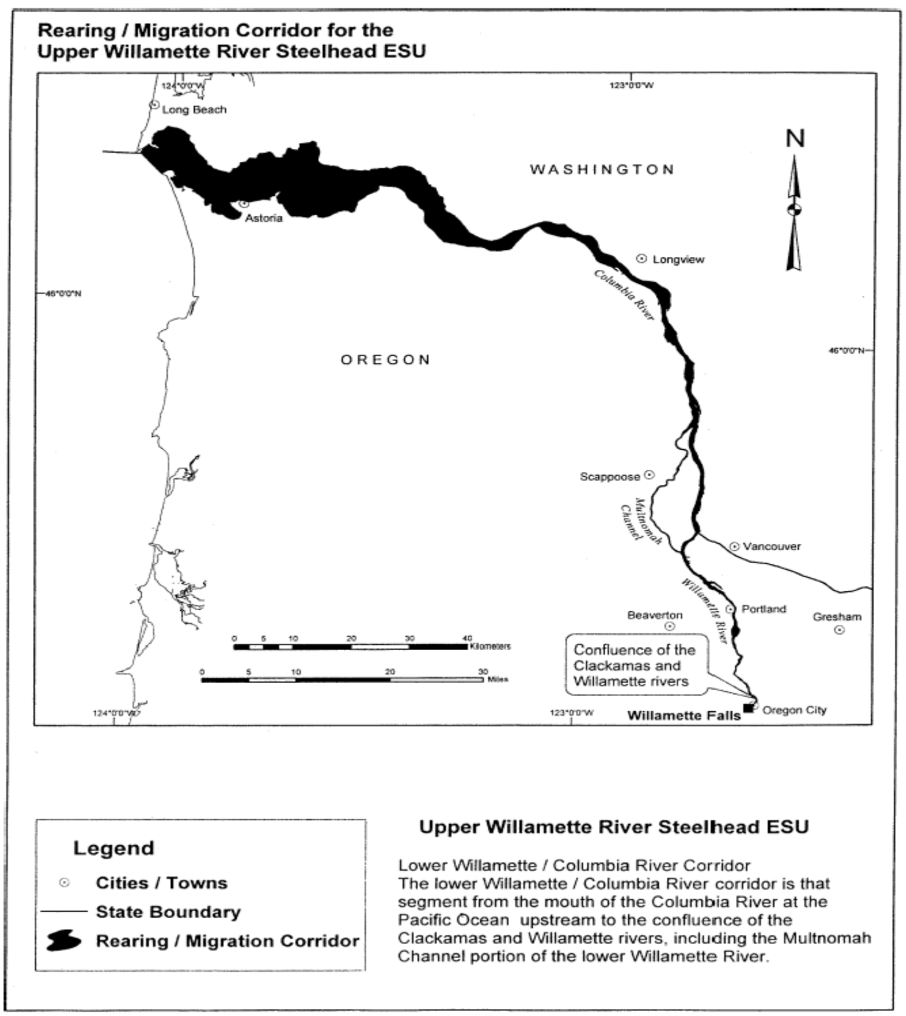

Figure 3-24 Critical habitat in the Lower Willamette/Columbia River corridor.

The CHART concluded that the Lower Willamette/Columbia River corridor was of high conservation value to the UWR steelhead DPS (NMFS 2005g).

In its final designation, NMFS included the entire corridor as critical habitat (NMFS 2005d).

3.3.3 Critical Habitat for Other ESU/DPSs

Summary information below describes the rangewide status of critical habitat for the other listed Columbia River basin ESUs/DPSs.

3.3.3.1 Critical Habitat for LCR Chinook

Designated critical habitat for LCR Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Lower Columbia, Grays/Elochoman, Clackamas, and Lower Willamette (NMFS 2005d). There are 48 watersheds within the range of this ESU. Four watersheds received a low rating, 13 received a medium rating, and 31 received a high rating of conservation value to the ESU. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 1,655 miles of habitat eligible for designation, 1,311 miles of stream are designated critical habitat.

3.3.3.2 Critical Habitat for LCR Steelhead

Designated critical habitat for LCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Upper Cowlitz, Cowlitz, Clackamas, and Lower Willamette (NMFS 2005d). There are 32 watersheds within the range of this DPS. Two watersheds received a low rating, 11 received a medium rating, and 29 received a high rating of conservation value to the DPS. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 2,673 miles of habitat eligible for designation, 2,324 miles of stream are designated critical habitat.

3.3.3.3 Critical Habitat for Columbia River Chum

Designated critical habitat for CR chum salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the White Salmon River as well as specific stream reaches in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Cowlitz, Lower Columbia, and Grays/Elochoman (NMFS 2005d). There are 20 watersheds within the range of this ESU. Three watersheds received a medium rating and 17 received a high rating of conservation value to the ESU. The lower Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 725 miles of habitat areas eligible for designation, 708 stream miles are designated critical habitat.

3.3.3.4 Critical Habitat for Mid-Columbia River Steelhead

Designated critical habitat for MCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Yakima River as well as specific stream reaches in the following subbasins: Upper Yakima, Naches, Lower Yakima, Middle Columbia/Lake Wallula, Walla Walla, Umatilla, Middle Columbia/Hood, Klickitat, Upper John Day, North Fork John Day, Middle Fork John Day, Lower John Day, Lower Deschutes, Trout, and Upper Columbia/Priest Rapids (NMFS 2005d). There are 114 watersheds within the range of this DPS. Nine watersheds received a low rating, 24 received a medium rating, and 81 received a high rating of conservation value to the DPS. The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in three of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 6,529 miles of habitat areas eligible for designation, 5,815 miles of stream are designated critical habitat.

3.3.3.5 Critical Habitat for Upper Columbia River Steelhead

Designated critical habitat for UCR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Okanogan, Similkameen, Methow, Upper Columbia/Entiat, Wenatchee, Lower Crab, and Upper Columbia/Priest Rapids (NMFS 2005d). There are 42 watersheds within the range of this DPS. Three watersheds received a low rating, 8 received a medium rating, and 31 received a high rating of conservation value to the DPS. The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 11 of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 1,332 miles of habitat areas eligible for designation, 1,262 miles of stream are designated critical habitat.

3.3.3.6 Critical Habitat for Upper Columbia River Spring Chinook

Designated critical habitat for UCR spring Chinook includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam as well as specific stream reaches in the following subbasins: Chief Joseph, Methow, Upper Columbia/Entiat, and Wenatchee (NMFS 2005d). There are 31 watersheds within the range of this ESU. Five watersheds received a medium rating and 26 received a high rating of conservation value to the ESU. The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 1,002 miles of habitat areas eligible for designation, 974 miles of stream are designated critical habitat.

3.3.3.7 Critical Habitat for Snake River Fall Chinook

Designated critical habitat for SR fall Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls and Dworshak and Hells Canyon dams) in the following subbasins: Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse. The lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high water line on each side of the river channel) (NMFS 1993). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005d).

3.3.3.8 Critical Habitat for Snake River Spring/Summer Chinook

Designated critical habitat for SR fall Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers, and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam. Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls, including Napias Creek Falls, and Dworshak and Hells Canyon dams) in the following subbasins: Hells Canyon, Imnaha, Lemhi, Little Salmon, Lower Grande Ronde, Lower Middle Fork Salmon, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon-Panther, Pahsimeroi, South Fork Salmon, Upper Middle Fork Salmon, Upper Grande Ronde, Upper Salmon, and Wallowa. The lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high water line on each side of the river channel) (NMFS 1999c). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005d).

3.3.3.9 Critical Habitat for Snake River Sockeye

Designated critical habitat for SR sockeye salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks); Alturas Lake Creek; and that portion of Valley Creek between Stanley Lake Creek and the Salmon River (NMFS 1993). The lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high water line on each side of the river channel) (NMFS 1993). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005d).

3.3.3.10 Critical Habitat for Snake River Steelhead

Designated critical habitat for SR steelhead includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in the following subbasins: Hells Canyon, Imnaha River, Lower Snake/Asotin, Upper Grande Ronde River, Wallowa River, Lower Grande Ronde, Lower Snake/Tucannon, Lower Snake River, Upper Salmon, Pahsimeroi, Middle Salmon-Panther, Lemhi, Upper Middle Fork Salmon, Lower Middle Fork Salmon, Middle Salmon-Chamberlain, South Fork Salmon, Lower Salmon, Little Salmon, Upper Selway, Lower Selway, Lochsa, Middle Fork Clearwater, South Fork Clearwater, and Clearwater (NMFS 2005d). There are 289 watersheds within the range of this DPS. Fourteen watersheds received a low rating, 44 received a medium rating, and 231 received a high rating of conservation value to the DPS. The lower Snake/Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. Of the 8,225 miles of habitat areas eligible for designation, 8,049 miles of stream are designated critical habitat.

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Chapter 4
Environmental Baseline

Section 4.1
General Baseline Perspective

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4 ENVIRONMENTAL BASELINE

SUMMARY OF ENVIRONMENTAL BASELINE

- Over the last century and a half, habitat degradation, hatchery influences, harvest rates and dams have adversely affected spring Chinook and winter Steelhead populations and their designated critical habitat.
- The quantity and quality of remaining spawning and rearing habitat has been significantly degraded by multiple factors. The dams have major impacts on both species in terms of flow, water temperature regime, downstream sediment and large wood transport, and channel complexity.
- The construction of the Willamette Project dams has blocked access to a substantial proportion of the historical habitat and has adversely affected habitats downstream. The best quality habitat is located in the headwater areas, with many of these areas not accessible to fish due to the impassable dams. The dams also have major impacts on both species in terms of flow, water temperature regime, downstream sediment and large wood transport, and channel complexity.
- Hatchery Chinook have significantly affected the genetic integrity of all Chinook populations. Hatchery fish spawning in the wild with natural-origin fish has been extensive.
- Fishery harvest levels were high in the past, but have now been reduced significantly. Harvest is no longer a limiting factor for Willamette Chinook and steelhead.

The "environmental baseline" for Biological Opinions is defined in the ESA section 7 implementing regulations as:

> "the past and present impacts of all Federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process" (50 CFR §402.2)

The ESA Section 7 Consultation Handbook (USFWS and NMFS 1998) further states that the environmental baseline is:

> "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem within the action area. The environmental baseline is a "snapshot" of a species' health at a specified point in time."

NMFS' analysis of conditions in the environmental baseline begins with a brief discussion of factors that affect multiple populations followed by discussions of conditions in each tributary basin, starting with the Middle Fork Willamette basin and progressing northward culminating with a discussion of conditions in and around the mainstem Willamette River, in the lower Columbia River, Estuary and plume.

4.1 GENERAL BASINWIDE PERSPECTIVE

The Willamette River Basin (Figure 4.1-1) historically supported large numbers of spring Chinook and winter steelhead. The diversity of habitats, ranging from the cold, snow-melt headwater streams in the Cascade Mountains downstream to the meandering and highly complex Willamette River, produced diverse and productive populations of salmon and steelhead. Historical populations had multiple juvenile life history types and adults returned at higher ages than is currently the case (Willis et al. 1995). Juvenile salmon and steelhead reared in the headwater streams and the mainstem Willamette River. Juveniles emigrated to the ocean over a number of months, with spring and fall migrations predominating.

Over the last 150 years UWR Chinook salmon and UWR steelhead have been adversely affected by dams, habitat degradation, fishing, and interactions with hatchery-origin fish. In the late 1800s, fish harvest in the Lower Columbia River had the most profound effect on Willamette runs, already causing noticeable declines in run sizes by 1878 (Stone 1878). In the early 1900s, European colonization of the Willamette Basin increased rapidly, with associated development and natural resource extraction greatly affecting the quality of salmonid habitat. Discharge of pollution by timber and paper mills into the mainstem Willamette River was so severe that massive die-offs of aquatic species including salmon and steelhead were prevalent. The problem was severe and public outcry to clean up the mainstem Willamette began as early as the late 1930s.

Figure 4.1-1 Principal Corps of Engineers facilities in the Willamette Basin

The Draft Willamette Salmon and Steelhead Recovery Plan (ODFW 2007b) identifies the most important key and secondary limiting factors and threats impacting spring Chinook and winter steelhead in the Willamette Basin. Limiting factors are the physical, biological, or chemical conditions experienced by the fish that limit their natural production or VSP attributes (McElhany et al. 2000). Threats are activities that have an effect on the fish and/or the environmental conditions they need to survive and reproduce. The limiting factors and threats are discussed in more detail for each of the populations, below. However, the following is a general summary of the key and secondary limiting factors and threats that have been identified in the Draft Recovery Plan (ODFW 2007b):

Spring Chinook Salmon

- Impaired access to habitat above hydropower/flood-control dams throughout the Willamette Basin.
- Direct mortality of juvenile fish associated with downstream passage through the hydropower/flood-control dams and reservoirs.
- Prespawning mortality of adult Chinook over-summering below the hydropower/flood-control dams.
- Hatchery Chinook interbreeding with natural-origin fish resulting in a risk of genetic introgression.
- Predation and competition with hatchery fish of all species.
- Altered water temperature regimes downstream of the hydropower/flood-control dams.
- Altered habitat conditions downstream of the hydropower/flood-control dams caused by reduced peak flows, reduced large woody debris, and reduced substrate recruitment.
- Altered habitat conditions in the tributaries caused by land management activities.
- Toxicity due to agricultural, urban, and industrial practices.
- Degraded estuarine habitat.

Winter Steelhead

- Altered habitat conditions caused by land management activities (timber, agricultural, urban).
- Toxicity due to agricultural, urban, and industrial practices in tributaries and mainstem Willamette.
- Impaired access to habitat above hydropower/flood-control dams throughout the Willamette Basin.
- Direct mortality of juvenile fish associated with downstream passage through the hydropower/flood-control dams and reservoirs.
- Hatchery fish interbreeding with natural-origin fish resulting in a risk of genetic introgression from use of an out-of-DPS stock (summer steelhead).
- Predation and competition with hatchery fish of all species.
- Altered water temperature regimes downstream of the hydropower/flood-control dams.
- Unscreened diversions create impediments and barriers to juvenile steelhead.
- Altered habitat conditions downstream of the hydropower/flood-control dams caused by reduced peak flows, reduced large woody debris, and reduced substrate recruitment.

- Degraded estuarine habitat.
- Interactions with non-native fish species.

4.1.1 Project Effects in the Environmental Baseline

4.1.1.1 Blockage of Upstream Habitats

From the late 1940s through the1960s, construction of 13 dams by the USACE blocked access to the majority of historical habitat for spring Chinook and, to a lesser extent, winter steelhead (Figure 4.1-2). Because these dams were high-head storage dams greater then 200 feet in height, volitional upstream fish passage (e.g. fish ladders) was considered to be infeasible and no fish passage facilities were built at most of the dams (USACE 2000). At some Project dams, traps were built to lift or transport adults upstream and simple collection devices for downstream juvenile migrants were used. Injury and mortality associated with these early systems greatly reduced the productivity of salmon and steelhead populations despite access to historical habitat above these dams. Fisheries managers tried to compensate for lost production with hatchery supplementation until improved passage facilities became feasible. From the 1960s to the present, as wild Chinook runs have precipitously declined, hatchery fish have made up a greater proportion of the returns. Human population growth and land development on the floodplain continued to increase, with the Willamette Basin now supporting approximately 75% of the human population of the state of Oregon. Habitat quantity and quality in the low elevation reaches below the dams has declined in response.

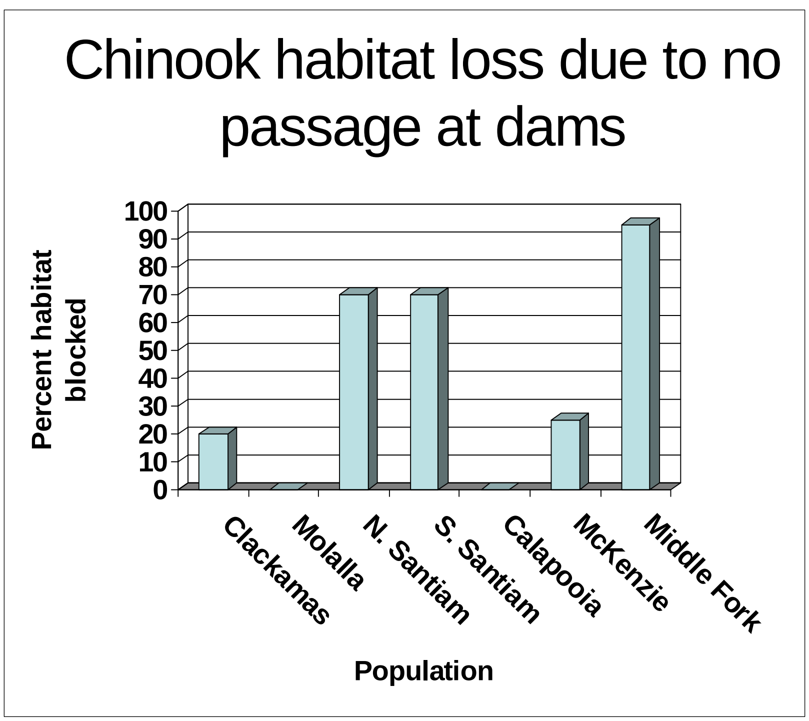

Figure 4.1-2 Percent of historic Chinook salmon spawning area in Willamette Basin blocked by impassable Federal dams in each population area. Estimates provided by USACE (2007a).

4.1.1.2 Flow Alteration

By seasonally putting water into storage and releasing it later in the year, the large water storage facilities of the Willamette Project have affected the streamflow characteristics of each affected tributary and the mainstem Willamette River. The Willamette Project's large storage facilities are drafted each fall for flood control and refilled each spring for other uses. The Project can also cause unusually large discharge changes over very short periods. These hydrologic effects seasonally modify fish habitat characteristics in the stream reaches downstream from these facilities.

These effects are discussed in detail in the stream-segment specific discussions below (Sections 4.2 through 4.11).

4.1.1.3 Water Quality

Water Temperature Effects

Water development influences water temperatures through storage, diversion, and irrigation return flows. These changes in water temperatures have significant implications for anadromous fish survival.

Among the primary water temperature effects of recent Willamette Project operations is a phenomena termed: thermal inertia. Thermal inertia refers to the tendency for the temperature of water released from a reservoir to temporally lag the temperature of incoming water (Figure 4.1-3). For example, in Figure 4.1-3, water coming into the reservoir (labeled "□ - above") warms by mid-summer and then begins to cool, while that flowing out of the reservoir (labeled "+ - below") lags behind by nearly 100 days, not reaching highest temperatures until fall.

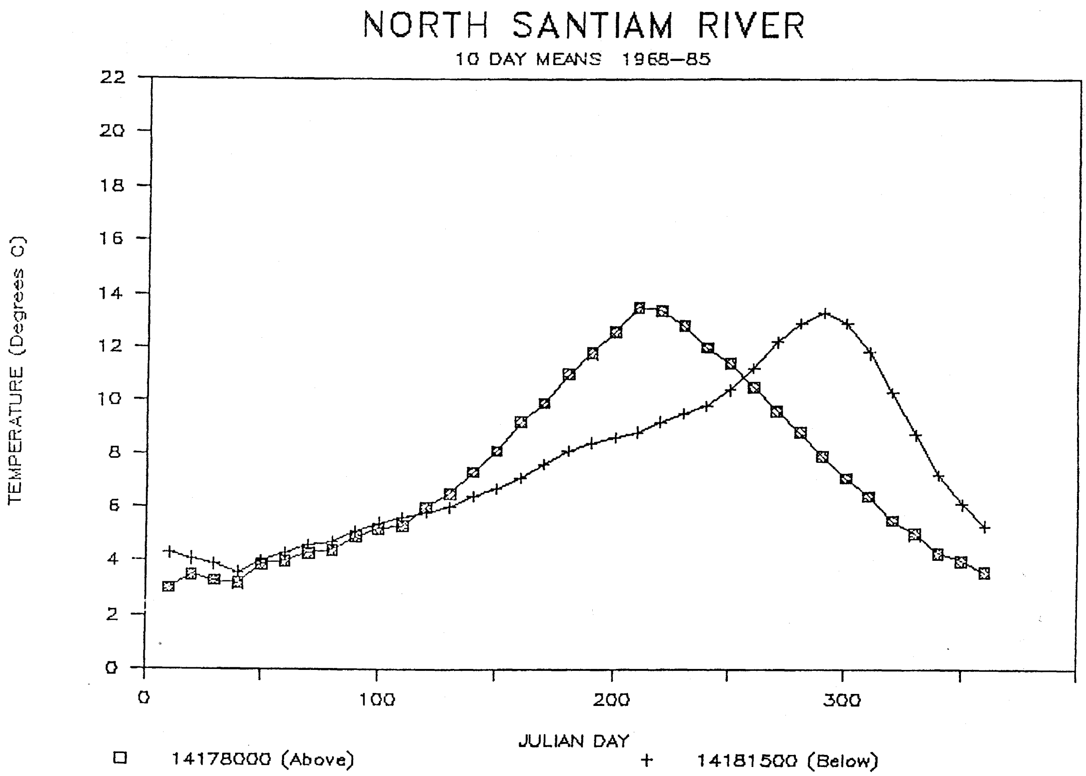

Figure 4.1-3 Water temperature changes caused by Detroit and Big Cliff reservoirs in the North Santiam River, 1968-1985.

Biological Effects

Thermal inertia changes the seasonal water temperature regime. Cooler water temperatures than normal in late-spring and early summer can delay upstream migration of UWR Chinook. For fall spawning species like UWR Chinook, warmer fall temperatures can delay spawning and accelerate incubation. Warmer fall temperatures can also exceed the thermal tolerance for incubating eggs, reducing viability. Eggs from spring spawning UWR steelhead develop more slowly at reduced temperatures. For both species, thermal inertia modifies emergence timing. Assuming that these fish are well adapted to the environment in which they evolved, such changes in emergence timing places the fish at a disadvantage. Ecological issues such as the abundance of predator and prey species changes through time. For example, an early-emerging Chinook alevin may have little to eat. Such thermal inertia effects may reduce the potential utility of habitat downstream from the dams and reduce the viability of the affected populations.

In 2003, EPA collaborated with NMFS and other regional resource managers to establish guidance for developing water quality standards. With regard to water temperature, the EPA reviewed the scientific literature and established recommended thresholds for a variety of salmonid life stage reactions (Table 4.1.-1).

Table 4.1-1 Summary of the EPA Water Temperature Guidelines and Potential Effects to Salmon. (Source: EPA 2003a).

LIFE STAGE	LIFE STAGE REACTION		THRESHOLD (°C)
Adult	Lethal (1 week exposure)		21-22
	Migration Blockage		21-22
	Disease Risk	High	18-20
		Elevated	14-17
		Minimized	12-13
	Swim Performance	Reduced	>20
		Optimal	15-19
	Overall Reduction in Migration Fitness		>17-18
Spawning	Spawning Behavior Observed in the Field		4-14
Eggs & Incubation	Good Survival		4-12
	Optimal Incubation		6-10
	Reduced Viability of Gametes		>13
Emergence & Juvenile Rearing	Lethal (1 week exposure)		23-26
	Optimal Growth	Unlimited Food	13-20
		Limited Food	10-16
	Rearing Preference Temperature		10-17
	Impaired Smoltification		12-15
	Disease Risk	High	>18-20
		Elevated	14-17
		Minimized	12-13

Of particular concern in the mainstem Willamette River is water temperatures during the spring emigration of steelhead smolts (April – June). At water temperatures above 15 ºC a parasitic myxosporean, *Ceratomyxa shasta,* becomes highly virulent, and recent research has shown that the probability of an outmigrating smolt returning as an adult is reduced when water temperatures exceed 15 ºC during outmigration (ODFW 2007b). Chinook salmon are somewhat more resistant to this disease but are also affected.

Global warming has increased average annual Columbia basin air temperatures by about 1 degree C over the past century, and water temperatures have been similarly affected (ISAB 2007). The influence of this and other large-scale environmental variations are discussed in Section 4.1.2 below.

Total Dissolved Gas

Spill at Project dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated total dissolved gas (TDG) conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring at nearby dams on the Columbia River shows that the incidence of GBT in both migrating smolts and adults remains between 1-2% when TDG concentrations in the upper water column do not exceed 120% of saturation. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. At times, TDG in Project dam discharges has exceeded 120% of saturation concentration.

4.1.2 Large-scale Environmental Variation

This section discusses inter-annual climatic variations (e.g. El Niño and La Niña), longer term cycles in ocean conditions pertinent to salmon survival (e.g., Pacific Decadal Oscillation), and ongoing global climate change and its implications for both oceanic and inland habitats and fish survivals. Because these phenomena have the potential to affect salmonid's survival over their entire range and multiple life stages, they are an area of substantial scientific investigation.

Salmonid population abundance is substantially affected by inter-annual changes in the freshwater and marine environments, particularly by conditions early in their life histories. Generally, the inland environment (including rivers, tributaries, and the associated uplands) is most favorable to salmon when there is a cold, wet winter, leading to substantial snowpack. This normally results in higher levels of runoff during spring and early summer, when many of the juvenile salmon are migrating to the ocean. The higher levels of runoff are associated with lower water temperatures, greater turbidity, and higher velocity in the river, all of which are beneficial to juvenile salmon. However, in years with exceptionally high snow pack and rain-on-snow events, severe flooding may constrain populations. The low return of Lewis River bright fall Chinook salmon in 1999, for example, has been attributed to flood events during 1995 and 1996.

Within the ocean environment, near-shore upwelling, which brings nutrients up from depth into the photic zone, is a key determinant of ocean productivity because it affects the availability of food for juvenile salmon at the critical time when they first enter the ocean. The upwelling results from ocean currents driven by spring and early summer winds which, in turn, result from oscillations in the jet stream that follow certain cycles. Within a year there are cycles of 20-40 days that affect upwelling and among years there are longer-lasting conditions, such as El Niño/La Niña, cycles of 2-3 years, and the Pacific Decadal Oscillation (PDO). The latter may have cycles of 30-40 years or more that influence upwelling.

Scheurell and Williams (2005) showed that the coastal upwelling index is a strong determinant of year-class strength and subsequent smolt-to-adult return ratios. The Northwest Fisheries Science Center currently monitors a number of ocean conditions and provides a forecast on their website for salmon returns to the Columbia River based on these and other observations.

In some instances, the inland conditions and ocean conditions appear to be correlated; that is, the same weather patterns producing a cold, wet winter with good snowpack and high spring runoff are also likely to bring the later winds that yield good upwelling and favorable feeding conditions in the ocean. However, it is also possible for inland and ocean conditions to diverge, and years have been observed where there have been favorable river conditions but poor ocean conditions, and vice versa.

While strong salmon runs are a product of both good in-river conditions and good ocean conditions, favorable ocean conditions appear to be especially important. For example, 2001 was the second-lowest flow year recorded on the Columbia River, but the near-shore temperatures were generally cool, observed ocean productivity was good, and resulting adult returns from the 2001 juvenile outmigration class were in the average or better range for most of the runs.

4.1.2.1 The Southern Oscillation Index, El Niño & La Niña

In an effort to predict the likely strength of the annual monsoons over India, which greatly affected human life through floods and famines, in the 1920s, Sir Gilbert Walker conducted extensive statistical analyses of long-term weather observations for many locations around the globe. Among his many findings was that deviations from long-term average seasonal differences in atmospheric pressure between the western Pacific and the eastern Pacific (typically Darwin, Australia, to Tahiti), were strongly correlated with subsequent climatic conditions in other parts of the globe. Walker termed these deviations, the “Southern Oscillation Index” (SOI). In general, substantial negative SOIs tend to correlate well with above average tropical sea-surface temperatures and positive SOIs tend to correlate with below average sea-surface temperatures, particularly in the eastern Pacific. Both have been found to have “teleconnections” to climatic and oceanic conditions in regions far distant from the south Pacific, including the Pacific Northwest. Although in modern usage a broader array of oceanic and atmospheric characteristics have been found to provide greater predictive power, these teleconnections between conditions in the south Pacific and subsequent climatic conditions elsewhere have come into routine use, including pre-season predictions of runoff in some portions of the Columbia basin.

Atmospheric conditions correlated with unseasonably warm south Pacific sea-surface temperatures are termed El Niños. El Niños typically last 6 to 18 months. Among the consequences are warmer near-surface ocean water temperatures along the U.S. west coast and generally warmer, drier weather in the inland Pacific Northwest, particularly during the winter. When winds do not blow south, the forces that create upwelling off the U.S. coast are reduced, as are nutrient inputs to the euphotic (well lit, near surface) zone, reducing near-shore ocean productivity. This reduction in ocean productivity has been shown to reduce juvenile salmon growth and survival (Scheurell and Williams 2005). Warmer surface waters can also change the spatial distribution of marine fishes, including potential predators and prey of salmon.

The warmer, drier weather in the Pacific Northwest often associated with El Niño can also cause or increase the severity of regional droughts. Droughts reduce streamflows through the Columbia and Snake River migratory corridor, increase water temperatures, and reduce the extent of suitable habitat in some drainages. Each of these physical effects has been shown to reduce salmon survival. Thus, El Niño events are associated with poor returns of salmon and steelhead.

Unseasonably cool south Pacific sea surface temperatures, typically associated with a positive SOI, tend to have quite different effects in the north Pacific and the Columbia basin. Termed La Niña, positive SOIs tend to be associated with cooler north Pacific surface water temperatures, and cooler, wetter fall and winter conditions inland. Conditions associated with La Niña tend to increase snowpack and runoff in the Interior Columbia basin, improving outmigration conditions through the lower Columbia River, and ocean conditions tend to be more conducive for coastal upwelling early in the spring, providing better feeding conditions for young salmon.

Currently, NOAA Physical Sciences Division calculates a "Multivariate El Niño Southern Oscillation Index" or MEI, which effectively inverts the SOI relationships: a positive MEI indicates El Niño conditions and a negative MEI a La Niña. Once established, El Niño and La Niña conditions tend to persist for a few months to two years although El Niño conditions have dominated the Pacific since 1977 and persisted from 1990 through 1995 (Figure 4.1-4 below). It is likely that the dominance of El Niño conditions since the late 1970s has contributed to the depressed status of many stocks of anadromous fish in the PNW.

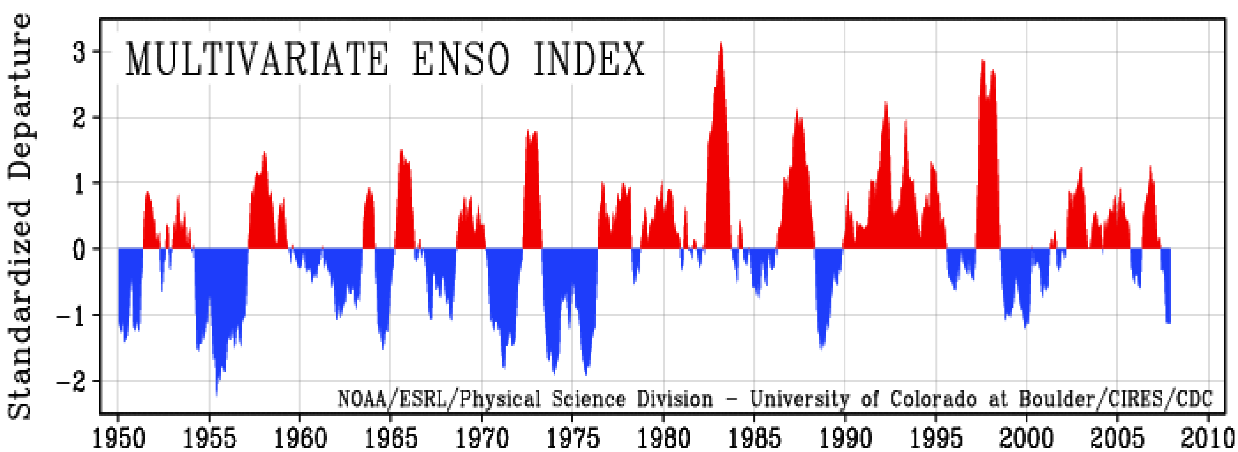

Figure 4.1-4 Time-series of MEI conditions from 1950 through November 2007. Source: NOAA 2008

4.1.2.2 Pacific Decadal Oscillation

First defined by Steven Hare in 1996, the Pacific Decadal Oscillation (PDO) index is the leading principal component (a statistical term) of variability in North Pacific sea surface temperatures (poleward of 20° N for the 1900-1993 period; JISAO 2008).

Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cool PDO eras have seen the opposite north-south pattern of marine ecosystem productivity (e.g., Hare et al. 1999). Thus, smolt-to-adult return ratios for Columbia basin salmon tend to be high when the PDO is in a cool phase and low when the PDO is in a warm phase.

Two main characteristics distinguish the PDO from El Niño: first, 20th century PDO "events" persisted for 20-to-30 years, while typical El Niño events persisted for 6 to 18 months; second, the climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics – the opposite is true for El Niño. Several independent studies find evidence for just two full PDO cycles in the past century: "cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid-1990s (Figure 4.1-5). Minobe (1997) has shown that 20th century PDO fluctuations were most energetic in two general periods, one from 15 to 25 years, and the other from 50 to 70 years.

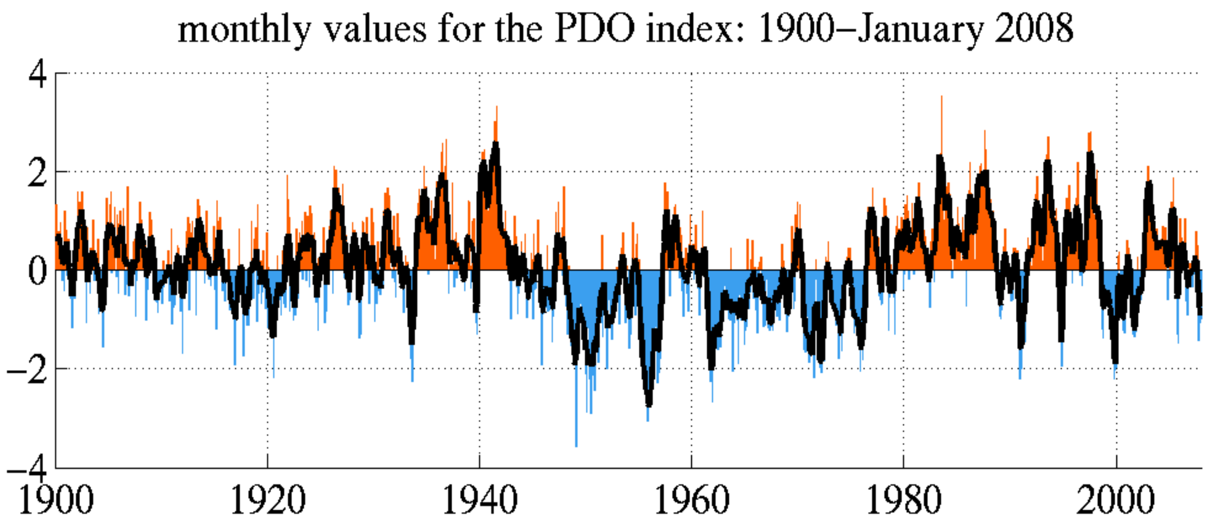

Figure 4.1-5 Monthly Values for the PDO Index: 1900-January 2008

Mantua and Hare (2002) state, "The physical mechanisms behind the PDO are not currently known." Likewise, the potential for predicting this climate oscillation is not known. Some climate simulation models produce PDO-like oscillations, although often for different reasons. Discovery of mechanisms giving rise to the PDO will determine whether skillful decades-long PDO climate predictions are possible. For example, if a PDO arises from air-sea interactions that require 10 year ocean adjustment times, then aspects of the phenomenon could, theoretically, be predictable at lead times of up to 10 years. Even in the absence of a theoretical understanding, PDO climate information improves season-to-season and year-to-year climate forecasts for North America because of its strong tendency for multi-season and multi-year persistence. From the perspective of societal impact, recognition of PDO is important because it shows that "normal" climate conditions can vary over time scales (decades) used to describe the length of a human's lifetime.

Recent evidence suggests that marine survival of salmonids fluctuates in response to the PDO's 20 to 30 year cycles of climatic conditions and ocean productivity (Cramer et al. 1999). Ocean conditions that affect the productivity of Northwest salmonid populations appear to have been in a low phase of the cycle for some time and to have been an important contributor to the decline of many stocks. The survival and recovery of these species will depend on their ability to persist through periods of unfavorable hydrologic and oceanographic conditions.

4.1.2.3 Global Climate Change

Ongoing global climate change has implications for the current and likely future status of anadromous fish in the Pacific Northwest. Recent studies, particularly by the Independent Scientific Advisory Board (ISAB 2007), describe the potential impacts of climate change in the Columbia River Basin. These effects, according to the ISAB, may alter precipitation and temperature levels in the basin and, in particular, impact the operation of the Willamette Project and the Federal Columbia River Power System and habitat used by rearing and migrating life-stages of salmon and steelhead. In the Columbia Basin, which relies on cooler winter temperatures to store a spring/summer water supply in the snowpack, alterations to precipitation and temperature levels may have the following physical impacts:

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, the snowpacks will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted earlier in the season, resulting in lower streamflows in the June through September period.
- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures will continue to rise, especially during the summer months when lower streamflow and warmer air temperatures will contribute to the warming regional waters.

Such responses to warming air temperatures and changing precipitation will not be spatially homogeneous across the entire Columbia River Basin. Following anticipated air temperature increases, the distribution and duration of snowpack in those portions of the basin at elevations high enough to maintain temperatures well below freezing for most of the winter and early spring would be less affected. Low-lying areas in the Interior, which historically have received scant precipitation, have contributed little to total streamflow. This condition would also be relatively unaffected. The most noticeable changes will occur in the "transient snow" watersheds such as the Willamette Basin where the threshold between freezing and non-freezing temperatures is much more sensitive to warming. Not only would changes in the distribution of precipitation between rain and snow affect the shape of the annual hydrograph and water temperature regimes, but more frequent and more severe rain-on-snow events could affect flood frequency with implications for scouring out incubating and young-of-the-year-fish (ISAB 2007).

The ISAB report also anticipates that large-scale ecological changes will occur over a 35-year time period. For example, the frequency and magnitude of insect infestations of forested lands and the frequency and intensity of forest fires are likely to become larger during this time period as well. As reported by the ISAB (2007), "fire frequency and intensity have already increased in the past 50 years, and especially the past 15 years, in the shrub steppe and forested regions of the West. Drought and hot, dry weather already have led to an increase in outbreaks of insects in the Columbia Basin, especially mountain pine beetle, and insect outbreaks are likely to become more common and widespread."[1] Such landscape changes have implications for salmon habitat and survival.

The ISAB (2007) identified the following list of likely effects of projected climate changes on Columbia basin salmon:

- Anticipated water temperature increases, and the subsequent depletion of cold water habitat, could reduce the areal extent of suitable inland salmon habitats. ISAB (2007) assessed the potential impacts of climate warming on Pacific Northwest salmon habitat. Locations that were likely to experience an average weekly maximum temperature that exceeded the upper thermal tolerance limit for a species were considered to be lost habitat. Projected salmon habitat loss would be most severe in Oregon and Idaho with potential losses exceeding 40% of current by 2090. Loss of salmon habitat in Washington would be a less severe case of about 22% loss by 2090. O'Neal's approach assumed a high rate of greenhouse gas emissions and used a climate model that projected a 5 degree C in global temperatures by 2090, a value that is higher than the scenarios considered most likely (ISAB 2007). This conservative estimate of potential habitat loss does not consider the associated impact of changing hydrology.
- Variations in intensity of precipitation may alter the seasonal hydrograph. With reduced snowpack and greater rainfall, the timing of stream flow will likely shift, depreciably reducing spring and summer stream flow, and increasing peak river flows (ISAB 2007). This reduction in stream flow may impact the quality and quantity of tributary rearing habitat, greatly affecting spring and summer salmon and steelhead runs. In addition, the Pacific Northwest's low late-summer and early-fall stream flows are likely to be further reduced. Reduced late-summer and early-fall flows, in conjunction with rising water temperatures, are likely to adversely impact juvenile fall Chinook and chum salmon by depleting essential summer shallow mainstem rearing habitat.
- Considering both the water temperature and hydrologic effects of climate change, Crozier et al. (2008) showed that the abundance of four studied Snake River spring/summer Chinook populations would be substantially decreased (20-50% decline from simulated average abundance based on historical 1915-2002 climate) and extinction risks substantially increased by long-term exposure to climate conditions likely to exist in 2040. Hydrologic and physical changes in the Pacific Northwest environment have implications for the habitat, populations, and spatial distributions of Pacific salmonids (Zabel et al. 2006).
- Eggs of fall and winter spawning fish, including Chinook, coho, chum, and sockeye salmon, may suffer higher levels of mortality when exposed to increased flood flows. Higher winter water temperatures also could accelerate embryo development and cause premature emergence of fry.

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[1] Removal of trees from riparian areas by fire or insects will lead, at least temporarily, to an increase in solar radiation reaching the water and exacerbate the water temperature. The potential for climate-induced fire and insect outbreaks has the potential to disproportionately impact habitats of key importance to native fish and wildlife populations (ISAB 2007).

- Increases in seasonal mainstem Snake and Columbia River water temperature would accelerate the rate of egg development of fall Chinook that spawn in the mainstem of the Snake and Columbia rivers, and lead to earlier emergence at a smaller average size than historically. Also, dam and reservoir passage survival is affected by water temperatures with the lowest rates of survival typically occurring when water temperatures are warmest. Potential impacts of increased water temperatures on adult salmon include delay in dam passage, failure to enter fish ladders, increased fallback, and loss of energy reserves due to increased metabolic demand. Increases in mortality also may be caused by fish pathogens and parasites as these organisms often do not become injurious until their host becomes thermally stressed.
- Earlier snowmelt and earlier, higher spring flows, warmer temperatures, and a greater proportion of precipitation falling as rain rather than snow, may cause spring Chinook and steelhead yearlings to smolt and emigrate to the estuary and ocean earlier in the spring. The early emigration coupled with a projected delay in the onset of coastal upwelling could cause these fish to enter the ocean before foraging conditions are optimal. The first few weeks in the ocean are thought to be critical to the survival of salmon off Oregon and Washington, so a growing mismatch between smolt migrations and coastal upwelling would likely have significant negative impacts on early ocean survival rates.
- Within the Columbia estuary, increased sea levels in conjunction with higher winter river flows could cause the degradation of estuary habitats created by increasing wave damage during storms. Numerous warm-adapted fish species, including several non-indigenous species, normally found in freshwater have been reported from the estuary and might expand their populations with the warmer water and seasonal expansion of freshwater habitats. Climate change also may affect the trophic dynamics of the estuary due to upstream extension of the salt wedge in spring-early summer caused by reduced river flows. The landward head of the salt wedge is characterized by a turbulent region known as the estuary turbidity maximum, an area with high concentrations of fish food organisms such as harpacticoid copepods. Changes in the upstream extension of the salt wedge will influence the location of this zone, but it is difficult to forecast the effect this change will have on juvenile salmon.
- Scientific evidence strongly suggests that global climate change is already altering marine ecosystems from the tropics to polar seas. Physical changes associated with warming include increases in ocean temperature, increased stratification of the water column, and changes in the intensity and timing of coastal upwelling. These changes will alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, survival, and migrations of salmonids.
- Changing ocean temperatures may alter salmon behavior, distribution, and migrations, increasing the distance to migrations from their home streams to ocean feeding areas. Energetic demands are increased at warmer temperatures, requiring increased consumption of prey to maintain a given growth rate. This could lead to intensified competition among species, as well as an increased reduction in growth rates, further exacerbating the prey/predator relationship. In addition, food availability in the ocean may be altered by climate change. Increasing concentration of CO_2 in the oceans lowers pH, which reduces the availability of carbonate for shell-forming marine animals. Pteropods are expected to be negatively affected, and they can comprise up to 40% or more of the diet of some salmon species, although another suitable prey item might replace them in the ecosystem. If salmon migrate farther to the north and/or food is less available, longer times may

be required to reach maturity, delaying the usual times of adult migrations into coastal water and rivers.

- Global climate change in the Pacific Northwest may be similar to those experienced during past periods of strong El Niños and warm phases of the PDO.

EPA (2008) presents a series of environmental indicators to measure current status and trends of the U.S. environment. Among the indicators presented is a nationwide evaluation of streamflow changes through time. This indicator shows that while both high flows and low flows have varied over the past 50 years, no long-term trend in either parameter was established. However, the national trend is toward a reduced annual variability in streamflow, likely a result of increased streamflow regulation (i.e. dams), not climate change.

An extensive hydrologic trend analysis was conducted for the Willamette River (Gregory et al. 2007). While substantial alteration of the natural hydrologic regime was identified by the analysis, the identified effects are attributable to the operation of Willamette Project dams, particularly operations designed to prevent flooding.

Given the broad natural variability in streamflow, the strength of short-term climate fluctuations and their effects on streamflow (e.g. El Nino), and the highly developed nature of the Willamette watershed, it will likely be difficult to identify climate-driven trends in Willamette basin streamflows from analysis of measured flow time-series until such effects are quite strong.

The effects of climate change are considered qualitatively in this Opinion. In addition, NMFS explicitly considers actions which are consistent with the ISAB's mitigation recommendations (see ISAB recommendations in Chapter 5.1 for further detail). However, the time frame, and the scope of climate change is not clear. Many climate change predictions describe changes up to 100 years. For the 15-year term of this Opinion, NMFS uses conservative assumptions and sets the stage for mitigation actions should they become necessary.

4.1.3 Water Diversions

Surface water is removed from the rivers and streams of the Willamette Basin for a multitude of municipal, industrial, and agricultural purposes. Most water diversions are relatively small, but cumulatively they have an impact, especially in localized situations, such as in tributaries with lower flows, or in water-deficit years. Water diversions present hazards for fish. Fish can be inadvertently intercepted and entrained into water flowing to municipal, industrial and agricultural uses, leading to their death. Some diversions are associated with small dams that can pose barriers to migration. The water removed from the stream reduces flow and water depth, reducing its quality as fish habitat. Most of the water diversions are small pumps, but some are gravity diversions.

Some surface water diversions in the Willamette Basin have had adequate fish protective measures installed, such as appropriate screens, but many have not and there is no current or pending requirement mandating fish protective measures to be installed at existing diversions. Most older diversions are not required under current State and Federal law to install and operate fish protective measures such as screens and thus are likely to continue to operate indefinitely without adequate fish protective measures.

Reclamation contracts to sell stored water impounded by the Willamette Project's USACE dams, thus providing a regulatory nexus to require fish protective measures for those diversions associated with these federal water contracts. However, these represent a small subset of all the diversions in the basin, and of the overall hazards presented by diversions within the Willamette Basin.

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Section 4.2
Middle Fork Willamette Baseline

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4.2 THE MIDDLE FORK WILLAMETTE

The Middle Fork Willamette River watershed is the largest tributary watershed in the Willamette River basin (Figure 4.2-1). The watershed is approximately 3,500 km^2 (865,000 acres) and is predominately forest land cover type (Figures 4.2-2). Eighty-two percent of the watershed is under public ownership (Figures 4.2-2, NRCS 2006a). The private land is predominately located at the lower end of the watershed below Dexter Dam near the city of Eugene.

Once a major producer of natural-origin UWR Chinook, the Middle Fork system now has salmon runs that are composed almost entirely of hatchery origin fish. Extensive salmon production areas in the system have been blocked by USACE dams, and conditions found in those areas still accessible to UWR Chinook below the dams appear insufficient to sustain a natural population. Habitat that remains available below the dams has been hydrologically, thermally, and structurally altered by land use practices and urbanization. Any naturally produced salmon returning to this habitat as adults must then share spawning areas with hatchery-origin spawners that stray from programs intended to offset the salmon production lost above the dams.

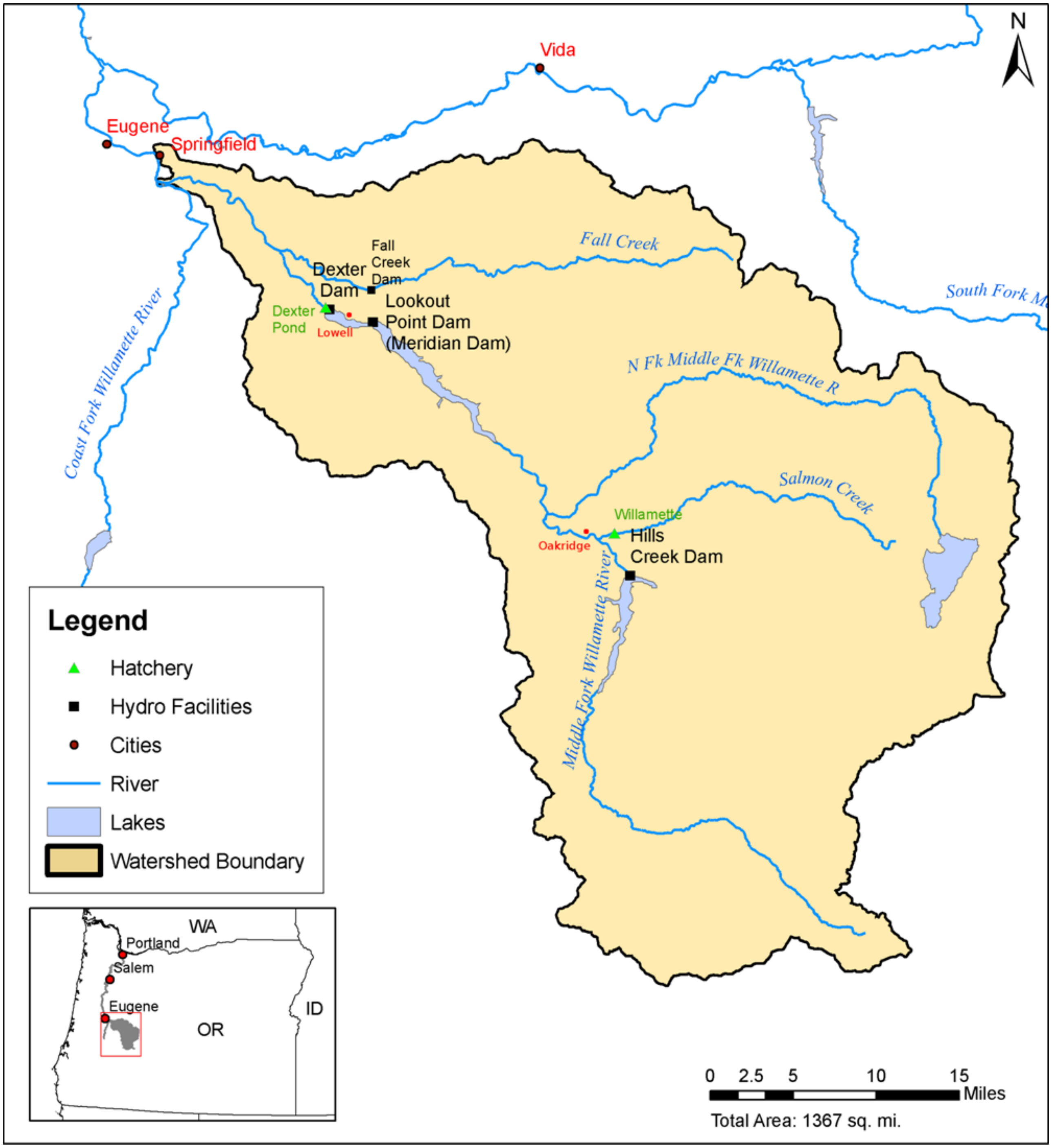


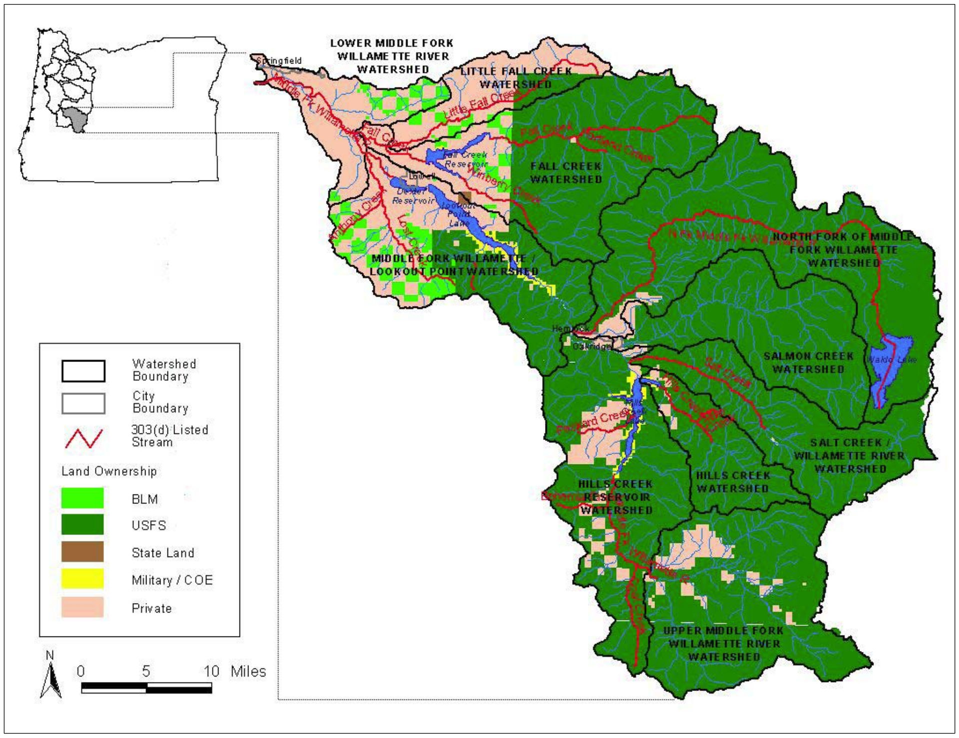
Figure 4.2-1 Map of the Middle Fork Willamette watershed. The uppermost extent of natural passage is near the town of Lowell, where Dexter and Fall Creek dams block upstream migration.

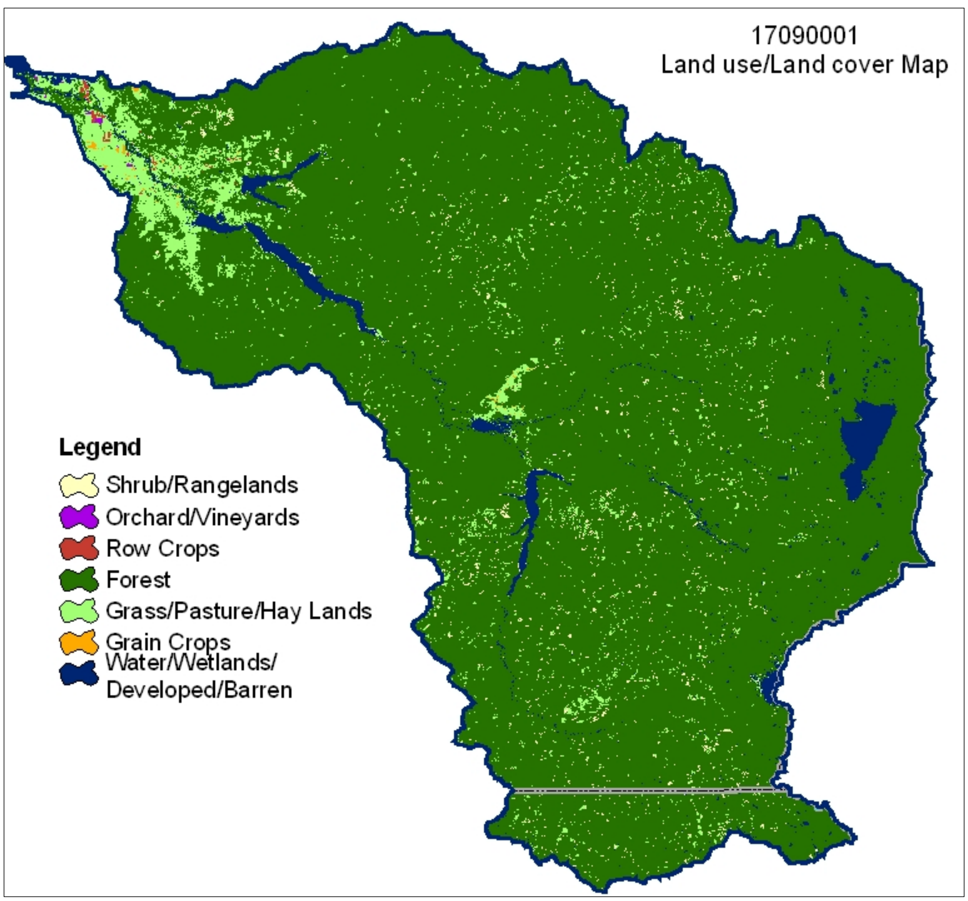
4.2.1 Historical Populations of Anadromous Salmonids in the Middle Fork Subbasin

The Middle Fork subbasin is home to a native run of UWR Chinook salmon but is not thought to be within the natural distribution of UWR steelhead. Historically, the run of UWR Chinook in the Middle Fork Willamette may have been the largest population of these fish above Willamette Falls (Hutchison 1966a; Thompson et al. 1966). McElhany et al. (2007) have suggested that the Middle Fork subbasin once likely produced tens of thousands of adult spring Chinook. Based on egg collections at the Willamette River Hatchery (Dexter Ponds; 1909 to the present), the largest egg collection, 11.3 million in 1918 (Wallis 1962), would correspond to 3,559 females (at 3,200 eggs/female) that escaped intense fisheries downstream in the lower Willamette and Columbia Rivers. This leads to an estimated minimum adult return to the subbasin of about 7,100 adult spring Chinook for the area that is now above Lookout Point Dam (assuming a 1:1 sex ratio). This estimate does not include fish that spawned downstream of the hatchery rack (such as in the lower mainstem Middle Fork Willamette and in the Fall Creek watershed). Mattson (1948) estimated adult returns of 2,550 naturally-produced spring Chinook to the Middle Fork subbasin in 1947. In the years immediately prior to Fall Creek Dam construction in 1966, there were about 450 spring Chinook salmon spawning in Fall Creek above the dam site USFWS (1962).

Mattson (1948) and Parkhurst et al. (1950) reported spawning aggregations of Chinook salmon in Fall Creek, Salmon Creek, the North Fork of the Middle Willamette River, the mainstem Middle Fork Willamette River, and Salt Creek. Mattson (1948) estimated that 98% of the 1947 run in the Middle Fork Willamette system spawned upstream of the Lookout Point dam site and the remaining 2% spawned upstream of the Fall Creek dam site.

From 1953 through 1966 (after construction of Dexter and Lookout Point Dams blocked access to most of the Middle Fork population’s historical spawning grounds), an average of 3,502 Chinook salmon were caught in the trap at the base of Dexter Dam (Wallis 1962; Hutchison et al. 1966b). These total counts probably included some hatchery-origin fish. Thompson et al. (1966) estimated a total population of 6,100 naturally- and artificially-produced adults in the Middle Fork Willamette subbasin below the dams in the mid-1960s.





Figures 4.2-2 Maps of the Middle Fork Willamette subbasin (ODEQ 2006a; top) and of land use patterns within the subbasin (NRCS 2006a, bottom).

4.2.2 Current Status of Anadromous Salmonids within the Middle Fork Willamette Subbasin

4.2.2.1 UWR Chinook Salmon

Population Viability

The Middle Fork population of UWR Chinook salmon is considered to be at very high risk of extinction, based on an analysis of its recent abundance, productivity, spatial structure, and diversity (McElhany et al. 2007). Chronically unfavorable conditions for the population within a dramatically reduced geographic range create most of this risk, but the potential for catastrophic events such as landslides and disease epidemics, is also a contributor (WLCTRT 2003).

Abundance & Productivity

The Middle Fork Willamette Chinook population's limited natural abundance and productivity pose a very high extinction risk (McElhany et al. 2007), an issue of particular concern given that it is a core population identified as critical to the long-term persistence of the ESU (see section 3.2.1.3 in Chapter 3, Rangewide Status). Abundances of wild spawners are low, pre-spawn mortality rates for these fish are high, and recent use of natural spawning areas has been dominated by fish of hatchery origin (Schroeder et al. 2006).

Adult UWR Chinook returning to the Middle Fork subbasin are counted at Dexter Dam, the upper limit of habitat that is now naturally accessible in the mainstem Middle Fork Willamette River, and at Fall Creek Dam as the USACE passes them into the watershed upstream. Counts of redds and spawned-out fish are conducted along the lower mainstem and on Fall Creek above the dam. Natural spawning apparently did not occur in the mainstem below Dexter before the dam was built (Lindsay et al. 1999). This indicates that the habitat below Dexter is not as high quality as that above the dams.

Numbers of adult UWR Chinook that have been counted at Dexter and Fall Creek dams during the years following dam completion are given in Figure 4.2-3. Annual counts at Dexter have varied from a low of 802 in 1960 to a high of nearly 18,000 in 1990, and have exceeded 5,500 adults since 2000. Wild fish are thought to have comprised a very small fraction of the Dexter counts except for the single generation of salmon whose adults were actually blocked from returning to their natal habitats. Annual returns to Fall Creek Dam averaged approximately 300 fish in the 1980s and about 150 fish during the 1990s, before exhibiting a recent upswing that apparently reflects improved ocean conditions and an expanded hatchery supplementation effort. The adult counts at Fall Creek Dam have for decades have been a mixture of naturally produced fish whose parents spawned above the dam combined with fish that were out-planted as juveniles into or below Fall Creek Reservoir in an effort to maintain natural production despite poor passage conditions at the dam.

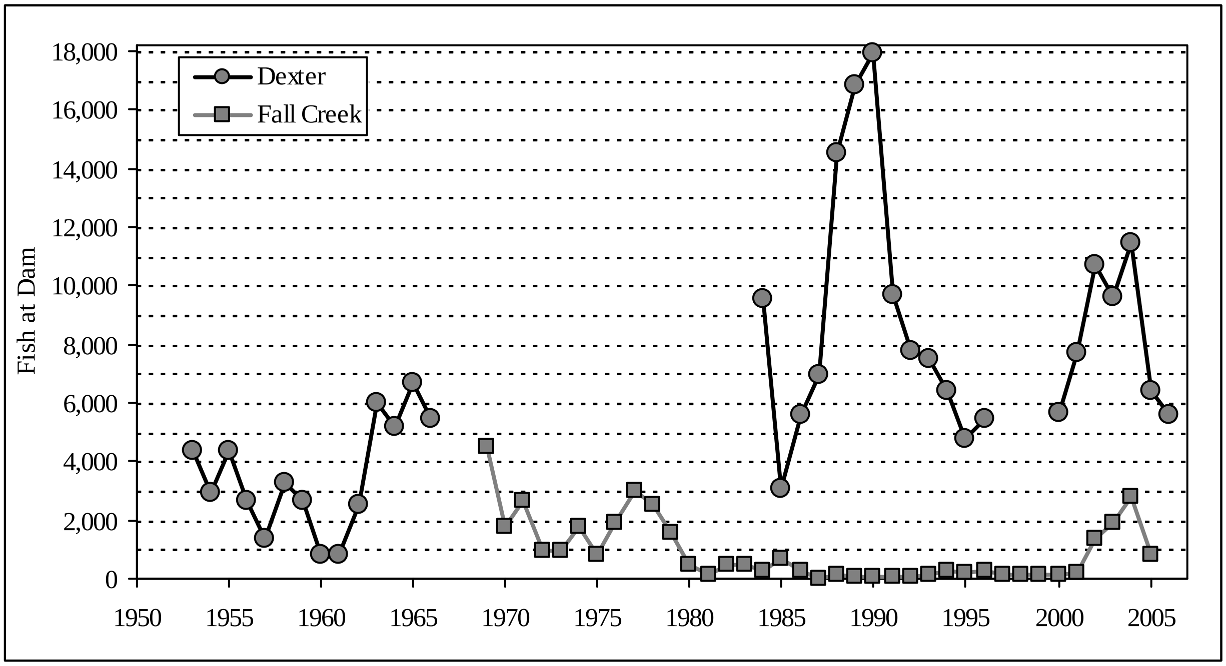


Figure 4.2-3 Hatchery-influenced counts of adult UWR Chinook salmon at Dexter and Fall Creek dams during the post-dam period (Streamnet trends 50886, 59338; Schroeder et al. 2006; McLaughlin et al. 2008)

Improvements to fish marking and monitoring efforts within the Willamette Basin now allow a high level of confidence in distinguishing hatchery-origin from wild (natural-origin) UWR Chinook. Under contract to the USACE, ODFW has since 2002 conducted intensive monitoring of hatchery and wild Chinook returning to Dexter Dam and to spawning areas in the lower Middle Fork, and in Fall Creek above Fall Creek Dam (Schroeder et al. 2006; McLaughlin et al. 2008). Monitoring results from 2002 through 2005 showed that returns of wild adults to the lower Middle Fork were very low, with an annual average of fewer than 50 captured at Dexter, and what appear to have been even lower numbers of wild spawners present in mainstem spawning areas between the town of Jasper[1] and Dexter Dam (Schroeder et al. 2006; McLaughlin et al. 2008). Hatchery fish accounted for 82-95% of the spawners in the lower river during the 2002-2005 period, and annual pre-spawn mortality rates averaged 92% (Schroeder et al. 2006; McLaughlin et al. 2008). This situation makes it unlikely that the lower river has sustained a "wild" population.

Recent monitoring by ODFW on upper Fall Creek indicates that it is more successfully used as a Chinook spawning area than is the mainstem Middle Fork, but the potential for the run of UWR Chinook in this stream to become self-sustaining without major passage improvements appears low. Although densities of Chinook redds (nests) have been substantially higher in Fall Creek above the reservoir than in the Middle Fork (Figure 4.2-4), the proportions of hatchery-origin spawners in the stream have been quite high (74-100%) (McLaughlin et al. 2008). Rates of pre-spawn mortality for adult UWR Chinook above Fall Creek Reservoir averaged 44-58% during the 2002-2005 period (Schroeder et al. 2006).

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[1] 7 miles below Dexter Dam, RM 195.

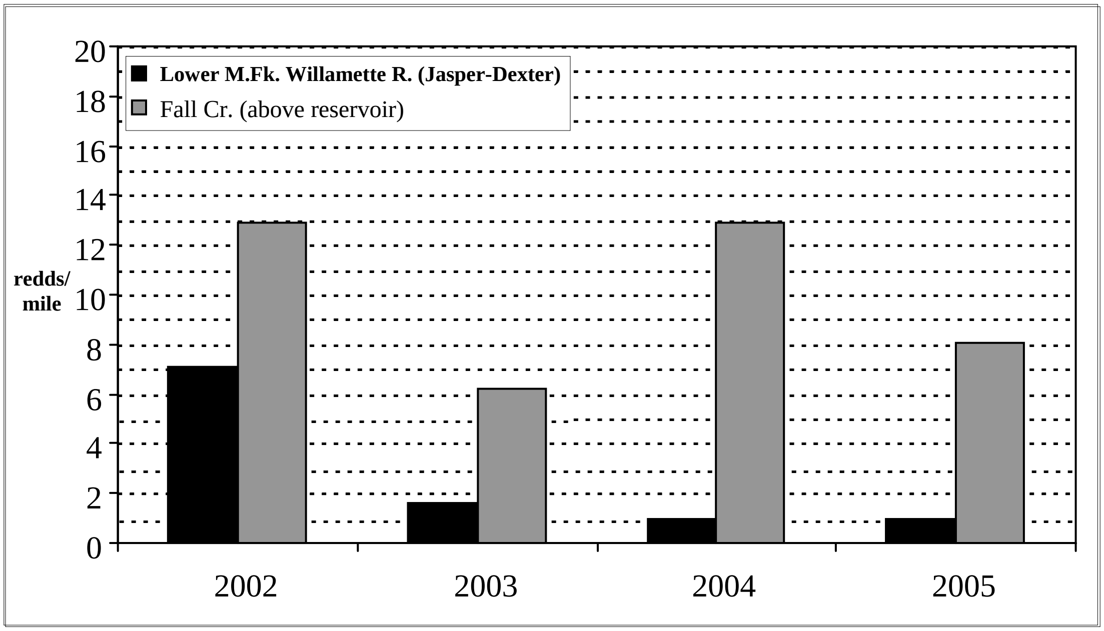


Figure 4.2-4 Spring Chinook redds (nests) per mile surveyed along the lower Middle Fork Willamette River and in Fall Creek above Fall Creek Reservoir, 2002-2005 (Schroeder et al. 2006).

Spatial Structure

The majority of the historical spawning areas of Middle Fork Willamette Spring Chinook have been blocked by dams, and the remaining naturally accessible habitats do not appear to provide the full suite of conditions needed to sustain a natural salmon population. This situation poses a high to very high risk of extinction to the persistence of what little remains of the subbasin's natural population of UWR Chinook (McElhany et al. 2007).

Diversity

The lack of diversity of the Middle Fork Willamette population of spring Chinook reflects a high risk of extinction, based on an examination of life history traits, effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity. Their greatest concern was the large proportion of hatchery-origin fish in natural spawning areas (McElhany et al. 2007).

4.2.2.1.1 Limiting Factors & Threats to Recovery for UWR Chinook salmon

The limiting factors and threats currently inhibiting the survival and recovery of UWR Chinook salmon in the Middle Fork Willamette watershed, as identified in the Draft Willamette Salmon and Steelhead Recovery Plan (ODFW 2007b), are shown in Table 4.2-1. Primary causes for the severely limited natural production of this species in the Middle Fork subbasin include blockage from critical habitat by Willamette Project dams, high pre-spawning mortality of adults, and altered water temperatures during egg incubation in the remaining habitat below the dams. Even though the limiting factors and threats are broken into two groups, key and secondary, the secondary factors are important to address as well as the key factors.

Table 4.2-1 Summary of key and secondary limiting factors and threats for Chinook in the Middle Fork Willamette watershed (ODFW 2007b). The entire life cycle limiting factors and threats assessment is found in section 4.1.

<table>
<tr><th rowspan="2">Threats</th><th rowspan="2">Species</th><th colspan="8">Tributaries
(Streams and Rivers within Population Area)</th></tr>
<tr><th>Egg</th><th>Alevin</th><th>Fry</th><th>Summer Parr</th><th>Winter Parr</th><th>Smolt</th><th>Adult</th><th>Spawner</th></tr>
<tr><td>Harvest</td><td>Chinook</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Hatchery</td><td>Chinook</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>3</td></tr>
<tr><td rowspan="2">Hydropower/ Flood Control</td><td rowspan="2">Chinook</td><td colspan="2">9f</td><td colspan="3" rowspan="2">10d</td><td rowspan="2">1f</td><td>2e</td><td rowspan="2">7f</td></tr>
<tr><td colspan="2">7g</td><td>2m</td></tr>
<tr><td rowspan="2">Landuse</td><td rowspan="2">Chinook</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">8a</td><td>8a</td><td rowspan="2">8a</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>9a</td></tr>
<tr><td>Introduced Species</td><td>Chinook</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

1f Mortality at Middle Fork Willamette hydropower/flood control dams. This mortality is due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.

2e Impaired access to habitat above Middle Fork Willamette hydropower/flood control dams.

2m Pre-spawning mortality due to crowding and high water temperatures below Middle Fork Willamette hydropower/flood control dams.

3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.

7f Lack of gravel recruitment below Middle Fork Willamette hydropower/flood control dams due to gravel capture in upstream reservoirs.

8a Impaired physical habitat from past and/or present land use practices (tributaries).

9f Elevated water temperatures below Middle Fork Willamette hydropower/flood control dams resulting in premature hatching and emergence.

10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Secondary threats and limiting factors

7g Streambed coarsening below Middle Fork Willamette hydropower/flood control dams due to reduced peak flows.

8a Impaired physical habitat from past and/or present land use practices (presmolts, Westside tributaries).

9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.

4.2.2.2 UWR Steelhead

Although native winter steelhead may have occasionally been present in the Middle Fork Willamette subbasin, the W/LC TRT concluded that this subbasin did not support an independent population, and the UWR steelhead DPS does not include steelhead in this subbasin (Myers et al. 2006). However, some winter steelhead are observed each year at Fall Creek, below Fall Creek Dam (ODFW 2002).

4.2.3 Environmental Conditions

Within the Middle Fork Willamette watershed, the USACE built four flood control and re-regulating dams since the late 1940's (see Figure 4.2-1). Dexter Dam (on the lower Middle Fork Willamette) and Fall Creek Dam (on lower Fall Creek) are the lowermost dams that block all volitional upstream migration of fish. Lookout Point Dam is located upstream from Dexter Dam. Hills Creek Dam is located upstream of Lookout Point Dam.

Below is a summary of past and ongoing effects of these dams and reservoirs on UWR Chinook salmon and their habitat in the Middle Fork Willamette. The effects are described in four broad categories: Habitat Access, Water Quantity/Hydrograph, Water Quality, and Physical Habitat.

4.2.3.1 Habitat Access

USACE's construction of impassable Willamette Project dams in the Middle Fork Willamette watershed adversely impacted this UWR Chinook population. These dams were built at low elevation in the watershed, eliminating access to nearly all significant habitat upstream (Figure 4.2-1) that UWR Chinook used for spawning and rearing, with the remaining accessible downstream habitat of marginal value. Egg to fry survival is very low in this remaining downstream habitat below Dexter Dam. This once large population now produces few natural-origin adult fish downstream from Dexter, the lowermost dam, and most spring Chinook that do spawn below the dam are of hatchery origin (Table 4.2-2).

Table 4.2-2 Estimated number of adult spring Chinook salmon carcasses in spawning areas that were of naturally produced ("wild"), local hatchery, and stray hatchery origin for the Middle Fork Willamette River (Dexter to Jasper), and including Fall Creek, 2002-2005 (Schroeder et al. 2006).

Year	Number of naturally produced origin	Number of local hatchery origin	Number of stray hatchery origin	Total	% wild
2002	15	318	0	333	5
2003	4	110	0	114	4
2004	22	152	0	174	13
2005	3	41	0	44	
4 year Average	11	155		166	7

4.2.3.1.1 Fish Passage at Dexter & Lookout Point Dams

Dexter and Lookout Point dams were built without fish passage facilities, but since construction of Dexter Dam in 1954, upstream migrating fish have been collected in a trap below Dexter dam (see Figure 4.2-1). For many years these fish were primarily taken to the Willamette Hatchery for spawning, but in 1993, ODFW began releasing some adult spring Chinook into areas above Dexter-Lookout Point and Hills Creek Dam. This outplanting effort originally was intended as a benefit to bull trout by providing nutrients to the stream environment from Chinook carcasses and a food source (juvenile Chinook). However, many of the outplanted Chinook reproduced naturally in their historical habitat, and juvenile Chinook were observed in the reservoirs and emigrating through the dams. Ziller (2002) estimated 162 redds in over 35 miles of habitat in the North Fork of Middle Fork Willamette River. Based on these results (and other encouraging observations elsewhere in the Willamette Basin), the outplanting program has transitioned into an effort to encourage natural production of spring Chinook salmon in recent years. Chinook are now released above the impassable dams to determine the feasibility of restoring natural production in the areas above the dams and reservoirs (Beidler and Knapp 2005, Table 4.2-3). Success of the outplanting program to date has been limited, though, partly due to high prespawning mortality of outplanted fish that has greatly reduced the number of spawning fish. The reasons for this high pre-spawning mortality are not well understood at this time, but it is speculated that trapping and handling effects, temperature effects, downstream habitat conditions, and timing effects are likely contributing to the poor survival rates observed. Additionally, because the outplanted fish in the Middle Fork Willamette River above Dexter Dam have all been hatchery-origin adults, NMFS would expect high pre-spawning mortality because these adults may be looking for a hatchery entrance rather than native spawning grounds. Upstream survival could be improved by upgrading fish collection facilities and transport and release operations consistent with NMFS criteria.

Limited data are available regarding downstream passage and survival of juvenile Chinook through Lookout Point and Dexter reservoirs and dams. In a 2001 and 2002 study, survival through the turbines at Lookout Point Dam was estimated at approximately 88% (Ziller 2002). Survival through the Kaplan turbines at Dexter is unknown but may be similar to the 92% measured at Foster dam (USACE 2007a). There are no downstream passage facilities for juvenile Chinook salmon at either Lookout Point or Dexter dams.

Table 4.2-3 Numbers of adult spring Chinook salmon in the Middle Fork Willamette subbasin released above USACE dams, including Fall Creek Dam, 1993-2006. Asterisk (*) indicated that some fish were also placed in Hills Creek. Source: (Mamoyac and Ziller 2001; Ziller 2002; McLaughlin et al. 2008; Beidler and Knapp 2005)

Year	Middle Fork, above Hills Creek Dam	Middle Fork above Lookout Point Reservoir			Fall Creek, above Fall Creek Dam
		North Fork Middle Fork	Middle Fork	Salt Creek	
1991	0	0	0	0	26
1992	0	0	0	0	84
1993	796	0	0	0	120
1994	177	0	0	0	64
1995	522	0	0	0	183
1996	341	0	0	0	145
1997	956	0	0	0	165
1998	572	0	0	0	158
1999	1,073	578	0	0	149
2000	2,006	798	0	0	187
2001	2,261	1,650	0	924	195
2002	2,793	3,765	535	1,367	1,381
2003	1,500	1,695	0	631	1,940
2004	2,416*	2,703	0	1,192	2,805
2005	1,052	298	0	405	802
2006	769*	827	0	381	613

4.2.3.1.2 Fish Passage at Fall Creek Dam

Fall Creek Dam was constructed in 1966 with fish passage facilities, namely a trap at the base of the dam for upstream migrating adults and a downstream migrant collector systems consisting of "fish horns" on the upstream face of the dam. However, as described in this section, the downstream passage system was not effective at safely collecting and passing fish, and the regulating outlets are now considered the primary downstream fish passage route.

The fish horn apertures were installed at the 800-, 765-, and 720-foot elevations on the upstream face of the dam to collect downstream migrants, but these proved to be ineffective. Smith and Korn (1970) assessed the passage of downstream migrants by releasing marked yearling Chinook salmon and 2-year-old winter steelhead at the head of the reservoir during 1966 through 1969 and collecting the smolts in the evaluator. Chinook smolt recoveries never exceeded 15.6%, and winter steelhead emigrated at even lower rates (Table 6 in Smith and Korn 1970). Smith and Korn attributed the poor collection efficiency to improper placement of the fish horns compared to the vertical distribution of emigrants in the reservoir, and to low attraction flow into the horns during much of the emigration period. Earlier studies had shown that smolted Chinook and steelhead inhabited the upper 15 feet of water, near the shoreline, during the spring months. In a year of average inflow at Fall Creek, the entrances to the transport system attracted fish from 30 feet below the surface of the reservoir and about 150 feet offshore from the face of the dam (Smith and Korn 1970). Smith and Korn recommended that the USACE continue to completely evacuate the reservoir in the late fall or early winter of each year as a means of passing emigrants through the outlets.

The USACE passed smolts by draining the reservoir in the fall, per Smith and Korn's advice, through 1977. After 1977, the reservoir was kept up through Labor Day (for recreation) and smolts were forced to exit through the two gates on the regulating outlet under high head and high flow. Downey and Smith (1992) estimated 19% to 29% survival under these conditions; injury and mortality generally increased with head and flow and the greatest injury and mortality rates were thought to occur as the fish passed under the gates. Downey and Smith (1992) estimated approximately 32% survival through the fish horn system, with most of the survivors receiving severe head and eye abrasions. Because lowering the reservoir during September and October would decrease the head and flow through the outlets, Downey and Smith (1992) recommended that reservoir operations be returned to a modified version of the pre-1977 operation. The recommended drawdown procedure was implemented from 1992 through 1998, but was halted when ODFW stopped rearing hatchery fingerlings in the reservoir in favor of releasing marked smolts below the dam. The horn system is now used to supplement the water supply to the adult collection facility during summer and early fall, and juveniles exiting the reservoir during that period also use that route. After the middle of October, when the fish ladder is shut down, outmigrants exit through the regulating outlet.

The existing adult fish trap at the base of Fall Creek Dam does not meet NMFS' current design criteria, although some improvements made in recent years have likely reduced fish handling stress and injury. USACE (2000) states that upstream migrants could experience abrasion, mechanical injury, and stress in the trapping facility and may experience delay in migration and disease when water temperatures are above maximum. Trucking and release upstream could lead to mechanical injury and could expose adults to low dissolved oxygen concentrations. Originally most adult spring Chinook salmon and some winter steelhead trapped at Fall Creek Dam were trucked to the McKenzie and other hatcheries, but some were released at a site about two miles above the edge of the reservoir. Beginning in 1998, all of the spring Chinook returning to the collection facility were released above the dam (USACE 2007a).

4.2.3.1.3 Fish Passage at Hills Creek Dam

Hills Creek Dam (RM 230) was built in 1961 on the Middle Fork of the Willamette River without upstream or downstream fish passage facilities. ODFW began releasing adult spring Chinook salmon above Hills Creek Reservoir in 1993 to increase nutrient inputs and to provide a prey base for bull trout. As at Lookout Point, occasional releases of hatchery-reared Chinook fingerlings were intended to augment the recreational trout fishery in Hills Creek Reservoir. In a 1999 and 2000 study, ODFW estimated survival of outmigrant Chinook through the turbines and regulating outlets at about 41% and 68%, respectively (Ziller 2002).

4.2.3.2 Water Quantity/Hydrograph

Flows have been controlled by the Lookout Point-Dexter project and Hills Creek and Fall Creek dams since 1954, 1961, and 1965, respectively. Operating the projects for flood control and other purposes has substantially altered the natural hydrologic regime (Figures 4.2-5 A, B & C).

Middle Fork Willamette River natural streamflow displays the same general seasonal distribution as other Willamette basin tributaries, with the majority of runoff occurring during the winter rainy season and low flows during July and August. Headwater elevations are high enough to develop a seasonal snowpack so the hydrograph exhibits a bimodal distribution, with a secondary peak due to snowmelt in May and June. Flows in the Middle Fork Willamette River are naturally highest in winter and spring and lowest in early fall (Figures 4.2-5 A, B & C). Operations of the Hills Creek, Lookout Point/Dexter, and Fall Creek projects have reduced the median daily April flow downstream from Dexter by 44% compared to the pre-dam condition. Median daily August flows have been increased by 185%.

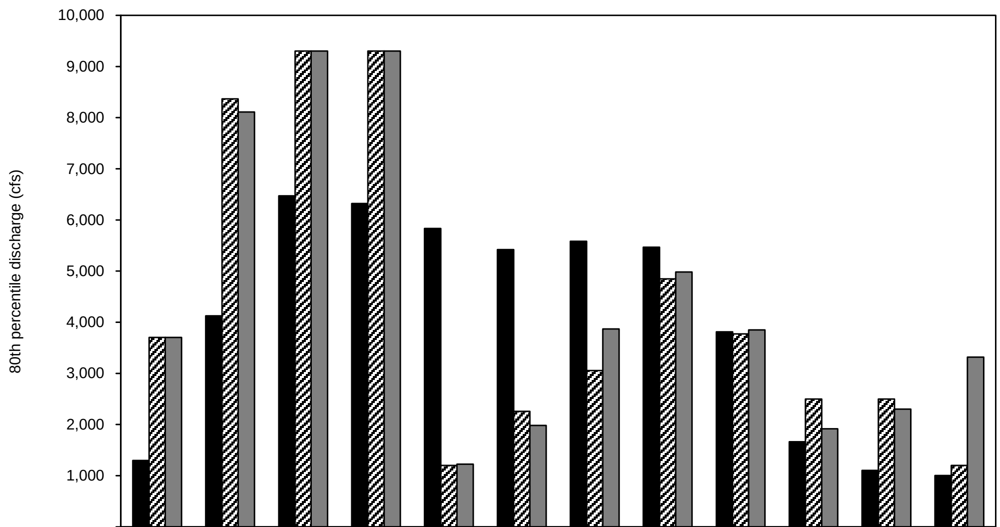
Flows in Fall Creek are naturally highest in the winter and early spring and lowest in late summer/early fall (Figures 4.2-6 A, B & C). Operation of the Fall Creek project has reduced the median daily April flow by 23% and has increased the median daily August flow by 418%.

Before dam construction, the lowest average daily flow observed at the Jasper gage in the lower Middle Fork, below the mouth of Fall Creek (USGS Station No. 14152000), was the 530 cfs observed on several occasions from September through November 1907. The lowest average daily flow observed at Jasper since all four Middle Fork projects were completed was 536 cfs in April 1977. An instantaneous minimum flow of 366 cfs was observed in December 1954, shortly after Lookout Point Dam was built. The minimum instantaneous discharge observed at the Fall Creek gage, downstream from Fall Creek Dam and the mouth of Winberry Creek (USGS Station No. 14151000), was 1.5 cfs, in October 1965.

The Middle Fork Willamette River is lightly used to supply water for domestic, industrial, and agricultural uses. The OWRD has issued permits for surface water withdrawals totaling 196 cfs from the Middle Fork Willamette River (OWRD 2003). This is a maximum diversion right and a smaller amount is actually diverted. Due to high level of development, the OWRD water availability process (OAR 690-400-001) has determined that natural flow water is not available for out-of-stream use from the Middle Fork Willamette River from February through November. Further, the Willamette Basin Program Classifications (OAR 690-502-0110) require that new surface water users in the subbasin obtain water service contracts from USBR (i.e., for the use of water stored in Willamette Project reservoirs during the summer months, including irrigation). The USBR has issued contracts for the delivery of 241 acre-feet of water annually (equivalent to about 1.2 cfs) from the Middle Fork reservoirs to users diverting from the Middle Fork Willamette River and Fall Creek (USACE 2007a).

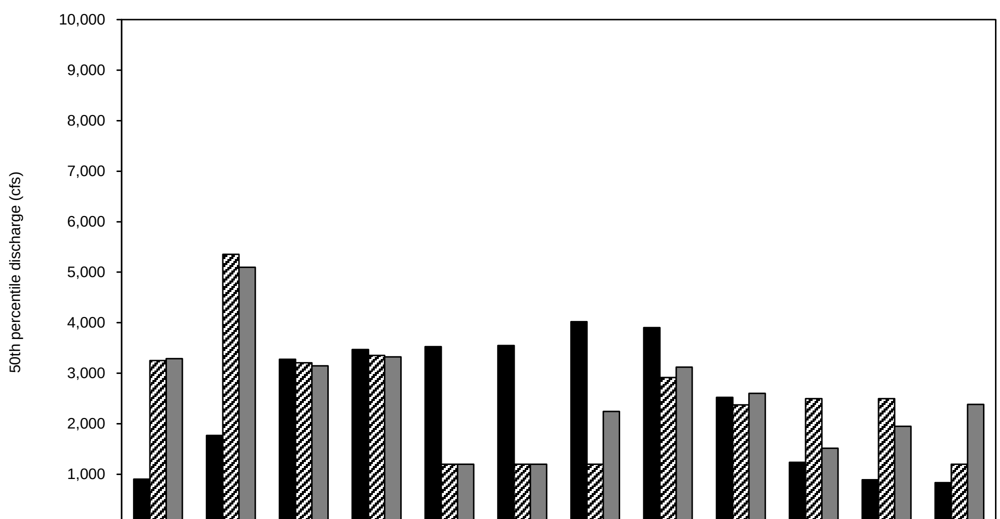
This modification of the Middle Fork's hydrologic regime has several implications for salmon and steelhead.

Figures 4.2-5 A, B & C. Simulated discharge (cfs) of Middle Fork Willamette River below Dexter Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile (respectively) for each scenario.



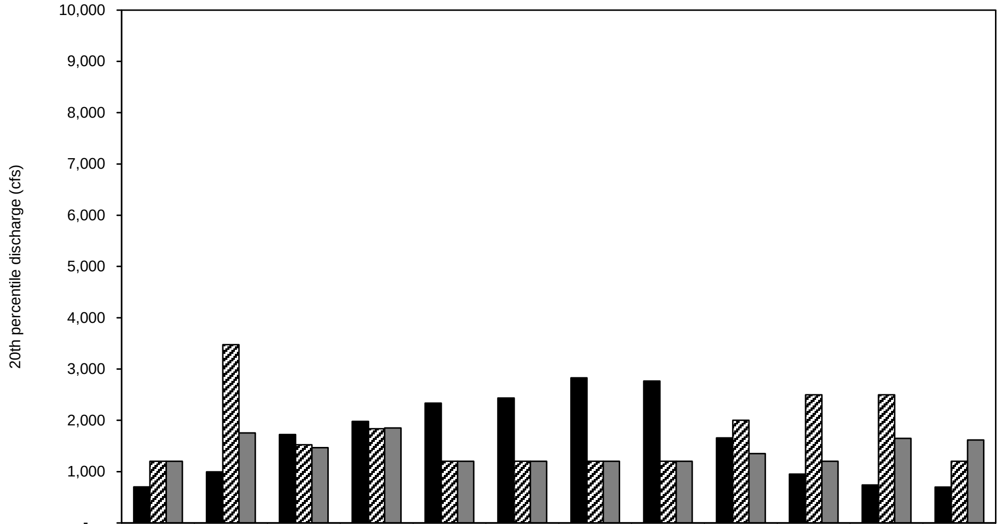
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	1,299	4,128	6,473	6,320	5,833	5,422	5,583	5,467	3,813	1,663	1,105	1,005
Pre-2000	3,704	8,366	9,300	9,300	1,200	2,258	3,055	4,848	3,771	2,500	2,500	1,200
Post 2000	3,705	8,112	9,300	9,300	1,226	1,982	3,868	4,985	3,850	1,917	2,302	3,319

Figure 4.2-5 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	906	1,772	3,277	3,471	3,528	3,551	4,023	3,904	2,523	1,237	894	836
Pre-2000	3,252	5,353	3,209	3,354	1,200	1,200	1,200	2,914	2,373	2,500	2,500	1,200
Post-2000	3,291	5,097	3,147	3,325	1,200	1,200	2,245	3,124	2,602	1,517	1,952	2,386

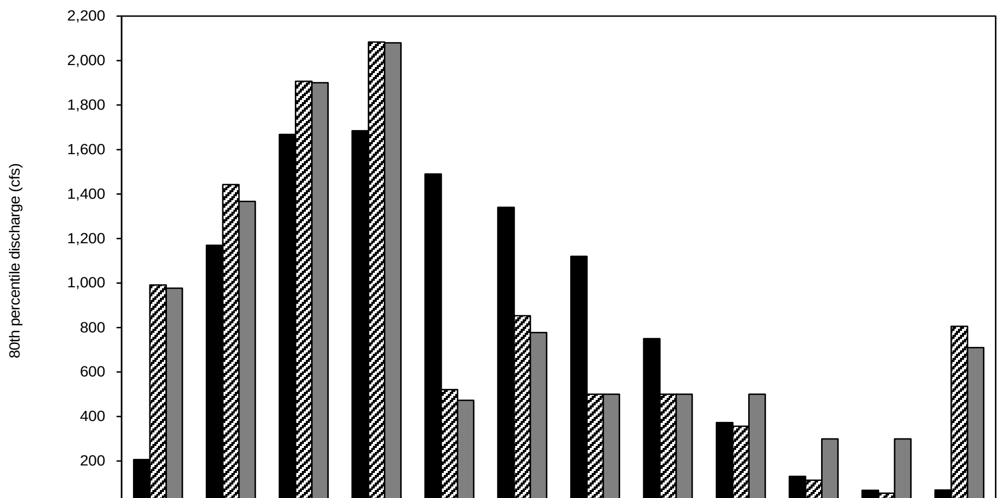
Figure 4.2-5 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	702	998	1,723	1,980	2,336	2,435	2,829	2,767	1,657	954	740	698
Pre-2000	1,200	3,476	1,524	1,836	1,200	1,200	1,200	1,200	2,000	2,500	2,500	1,200
Post-2000	1,200	1,754	1,467	1,850	1,200	1,200	1,200	1,200	1,350	1,200	1,648	1,616

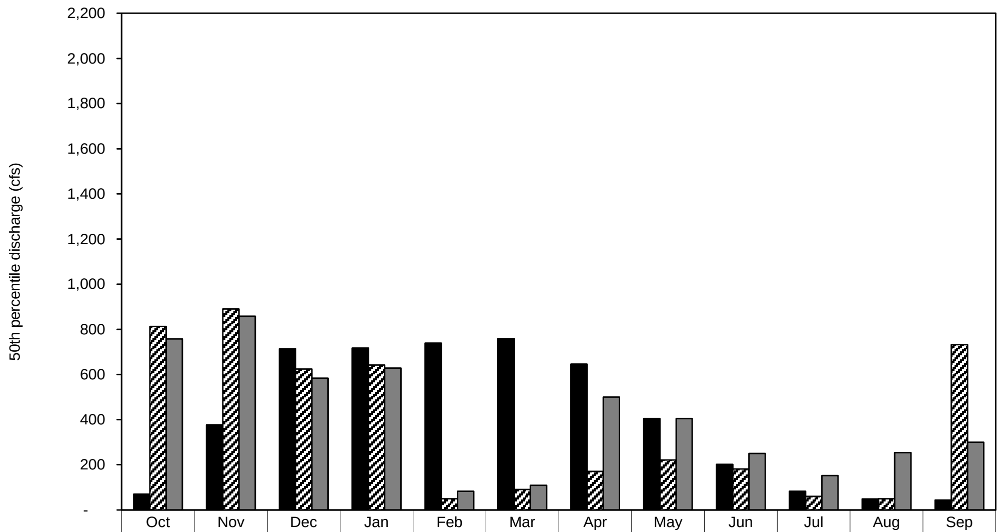
Figure 4.2-5 C

Figures 4.2-6 A, B & C. Simulated discharge (cfs) of Fall Creek below Fall Creek Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



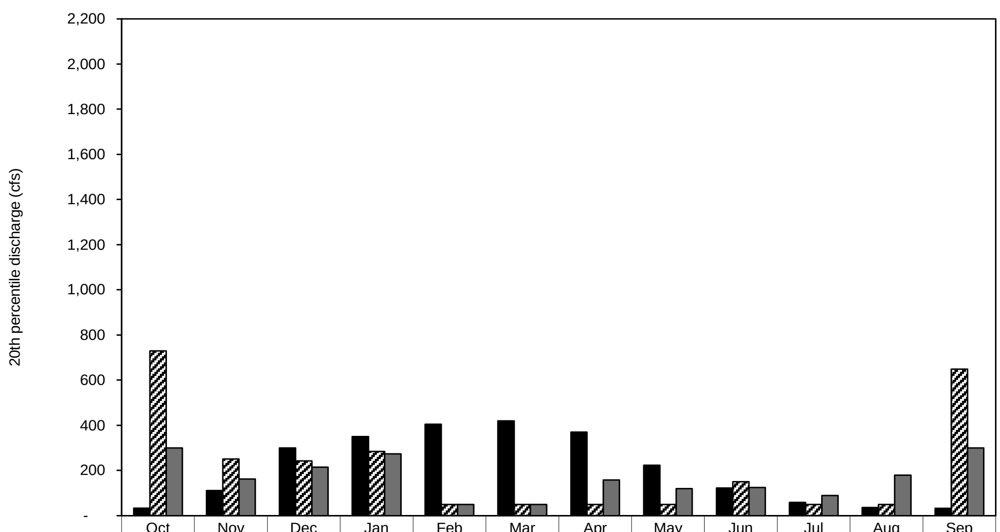
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	207	1,170	1,667	1,684	1,490	1,340	1,120	750	373	131	69	70
Pre-2000	991	1,442	1,907	2,083	522	853	500	500	357	114	55	805
Post-2000	977	1,367	1,900	2,079	473	777	500	500	500	300	300	710

Figure 4.2-6 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	70	377	714	717	739	759	646	405	202	83	49	44
Pre-2000	813	889	624	642	50	90	171	221	181	60	50	732
Post-2000	757	858	584	629	83	109	500	405	250	152	254	300

Figure 4.2-6 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	33	111	299	350	405	420	370	224	122	58	36	32
Pre-2000	730	251	242	284	50	50	50	50	150	50	50	649
Post-2000	300	163	214	274	50	50	158	120	125	89	179	300

Figure 4.2-6 C

4.2.3.2.1 Peak Flow Reduction

Flood control operations at the USACE dams have substantially decreased the magnitude and frequency of instantaneous peak flow events in the Middle Fork Willamette River. Flows greater than 20,000 cfs were common above Salt Creek (which enters the Middle Fork just above the town of Oakridge) before construction of Hills Creek Dam. Since construction of Hills Creek, no flows greater than about 10,000 cfs have occurred in this reach, and the magnitude of the 2-year recurrence interval event has decreased from 11,800 to 5,200 cfs (USACE 2000, Figure F-2). A similar peak flow reduction has been observed in Fall Creek, where the magnitude of the two-year recurrence interval event has decreased from about 10,000 to 3,800 cfs (USACE 2000, Figure F-6).

Reductions in peak flows caused by flood control operations at USACE projects within the Middle Fork Willamette River and its Coast Fork Willamette River tributary have contributed to the loss of habitat complexity in the Middle Fork Willamette River by substantially reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control tends to reduce channel complexity (e.g., reduces the frequency of side channels, and woody debris recruitment) and reduces the movement and recruitment of channel substrates. Side channels, backwaters, and instream woody debris accumulations have been shown to be important habitat features for rearing juvenile salmonids. Operation of USACE's dams is only partly responsible for the reduction in channel complexity noted in the Middle Fork Willamette River. Bank stabilization measures and land leveling and development in the basin have directly reduced channel complexity and associated juvenile salmon rearing habitat (see Section 4.2.3.4.1). Because of its unconfined nature, the river reach downstream from Dexter Dam has the greatest potential for alteration of its channel due to flow. As a result, however, reductions in peak flows affect it more strongly than other portions of the river, making it more susceptible to reductions in channel complexity.

Controlling peak flows prevents the flushing of fine sediments that accumulate on the river bed. Interstitial sediments finer than 1 mm can decrease the hydraulic conductivity of spawning gravels, reducing intragravel flow and the supply of oxygenated water to incubating eggs (Kondolf and Wilcock 1996). Somewhat coarser sediments (1 to 9 mm diameter) can fill interstices and physically block emergence of fry from the bed. Aquatic invertebrates also use open interstices in cobbles and gravel, and fine sediment can eliminate this habitat. The potential reduction in interstitial spaces may also affect juvenile salmonids, which are known to use interstitial spaces for cover during winter periods (Bjornn and Reiser 1991).

Controlling peak flows may beneficially affect incubating Chinook eggs and alevins by reducing the potential for redd scouring.

4.2.3.2.2 Altered Flow Effects on Spawning Success

Under the current project operations, when adults select spawning sites in late summer and early fall, the USACE releases higher flows than natural flows to draft the reservoirs for flood control. These higher flows allow the fish to select higher elevation spawning sites than would otherwise be available. Then, following spawning, lower minimum flows during active flood control operations during the winter can dewater these high-elevation redds, prior to emergence (USACE 2000, §6.1.1.6.; USACE 2007a, p 5-29). Depending on the duration and rate of desiccation, dewatering salmon redds can kill incubating eggs and alevins (Reiser and White 1983). The potential for these project-caused effects is greatest in the river reaches immediately below the dams (USACE 2000, §6.1.1.6.)

Taylor observed this effect below Dexter Dam when Chinook salmon spawned at higher elevation sites during high discharges, and then these redds were exposed when flows dropped during the incubation period (Taylor 2008a). This adverse effect is of particular concern below Dexter, where the last remaining naturally-accessible spawning area exists for fish that historically spawned above this site. There is less spawning habitat available below Fall Creek dam, and as noted above, ODFW transports all collected fish to release locations above the dam rather than leave them to spawn in this more unsuitable habitat. However, the USACE notes that adults have been stranded during some historical abrupt flow variations from 150 cfs to 50 cfs, and bank stability and invertebrate production might have also been adversely affected during ramping (USACE 2000, §6.1.1.10.)

4.2.3.2.3 Flow Fluctuations, Entrapment, and Stranding

The Middle Fork Willamette River is subject to rapid water level fluctuations, particularly when flows are reduced abruptly to prevent downstream flooding. Discharges can also fluctuate over the course of the day to meet peak demand for power generation. At the Hills Creek project, discharge can vary between 300 and 1,500 cfs daily depending on seasonal conditions, although the facility is operated primarily as a base load project with relatively steady flows. Historically, the USACE limited ascending ramp rates at Hills Creek to protect the public from dangerous surges in river elevation downstream, but the downramping rate was allowed to reach 4,000 cfs per half-hour. Discharge due to load-following operations at Lookout Point Dam varies between zero and 8,100 cfs over a 24-hour period, but these fluctuations are re-regulated at Dexter Dam downstream. Historically, the maximum permissible downramping rate at Dexter Dam ranged between 700 and 5,000 cfs per hour during high flow periods, and between 300 and 700 cfs per hour during low flow periods. During low flows, ramping rates at Lookout Point Dam were designed to limit the rate of fall in tailwater surface elevations to 0.3 feet per hour and 0.5 feet per day (USACE 1989a).

Ramping operations at Lookout Point and Hills Creek dams were modified in 2006 to reduce fishery impacts. Currently, USACE attempts to maintain ramping rates of 0.1 ft. per hour at night and 0.2 ft. per hour during daylight hours except during active flood damage reduction operations. However, the USACE noted (USACE 2007a Table 3-5 footnote for nighttime ramping rates) that at lower flows several of their dams are unable to conform to recommended ramping rates. For example, at Hills Creek Dam on the Middle Fork, where flows sometimes can be down to 400 cfs, the USACE is unable to provide the recommended 0.1 ft/hr ramping rate when flows are lower than 1700 cfs, due to equipment limitations (USACE 2000, p. 6-26).

There are no hydropower facilities at Fall Creek Dam and discharge fluctuates primarily during flood control operations. However, in recent years USACE has occasionally sent pulsed discharges (i.e., a maximum of 150 cfs and minimum of 50 cfs within a 24-hour period) downstream to conserve water while trying to provide flows identified by ODFW as beneficial to juvenile salmon rearing (150 cfs). It is not known whether pulsing operations at Fall Creek have stranded and entrapped juvenile salmon or resulted in higher survival as intended.

Juvenile salmonids may become stranded and entrapped when discharge is reduced precipitously during power peaking and winter flood events. Additionally, as noted in this section, the USACE has limited ability to meet ramping rate restrictions at low flows, yet it is at these low flows when juvenile stranding is more likely to be a problem. This issue is of greatest concern downstream from Dexter Dam, the current upstream limit of the UWR Chinook salmon ESU, but may also be a concern in reaches above Dexter and Lookout Point dams for offspring of adult fish outplanted above Dexter Dam. As noted above in Section 4.2.3.1.1, outplanting of adults above Dexter Dam has resulted in natural production in areas upstream from Dexter Dam (Beidler and Knapp 2005). Power peaking operations and rapid discharge reductions at the Hills Creek Project have the potential to strand or entrap offspring of outplanted Chinook salmon in the Middle Fork Willamette from Hills Creek dam to Dexter Dam, including rearing fish in Dexter and Lookout Point reservoirs.

4.2.3.3 Water Quality

4.2.3.3.1 Water Temperature

Changes in seasonal temperature patterns in the lower Middle Fork Willamette River and in lower Fall Creek caused by the artificial reservoirs behind USACE dams have left much of the remaining habitat still accessible to UWR Chinook in the Middle Fork subbasin poorly suited to natural production.

The only remaining spawning habitat naturally accessible to spring Chinook are the areas below Dexter Dam and Fall Creek Dam (the extreme downstream area of the watershed as shown in Figure 4.2-1). Historically, spawning of spring Chinook was very unlikely in these lower reaches (Mattson 1948). The temperature regime of water released from the dams is significantly different than natural stream temperatures that the fish are naturally adapted to, as represented by water temperature of flow coming into the reservoir from upstream. Water released from the dams is colder mid-summer and warmer in the fall than streamflow entering the reservoir (Figure 4.2-7). Consequently, eggs incubating in the gravel below the dams are exposed to unnaturally high temperatures and the result has been a very low survival rate. Taylor and Garletts (2007) reported a 100% mortality rate of eggs incubating below Dexter Dam, compared to a 20% mortality rate of eggs incubating above the dam at the hatchery (Figure 4.2-8).

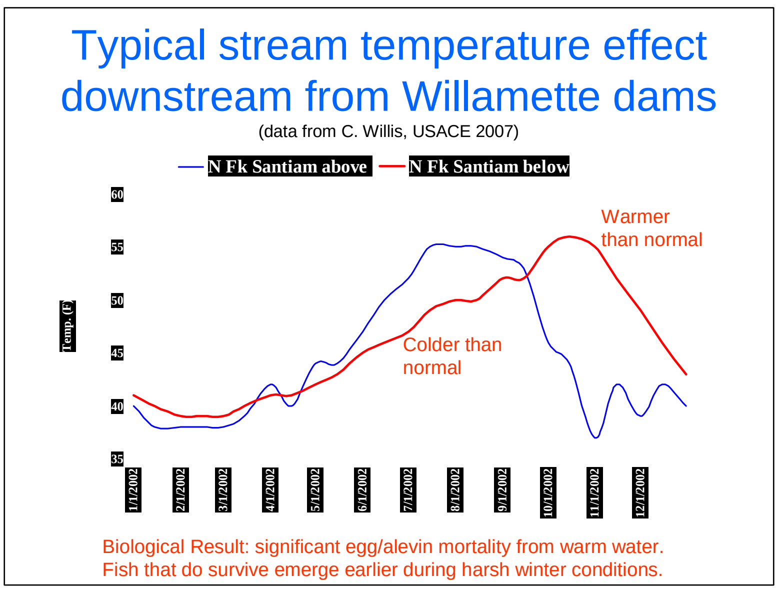


Figure 4.2-7 Typical example of altered stream temperature regime below Willamette flood control dams. Even though this data is specifically from the North Santiam subbasin, it is representative of the pattern observed in all Willamette subbasins.

Impacts of warm water temperatures on spring Chinook egg survival
(data from Taylor and Garletts , USACE 2007)

Location	Survival
Willamette Hatchery (upstream, natural temperature)	81%
Below Dexter Dam (downstream; altered temperatures)	0%

- 3,200 eggs from the same 32 pairs
- incubated in different locations
- monitored survival, incidence of fungus

Figure 4.2-8 Comparison of spring Chinook egg survival above and below Dexter Dam. Data from Taylor and Garletts 2007, USACE 2007a.

Water Temperature affected by Dexter & Lookout Point Dams

Operations of the Dexter/Lookout Point dam complex have altered the temperature regime below Dexter Dam. The temperature of water flowing into Lookout Point Reservoir peaks at 62°F (16.7°C) in July, while outflow temperatures peak at 59°F (15°C) two months later (USACE 2000, p. 6-55). The ODEQ's 2004/2006 Integrated Report database indicates there are insufficient data to determine if summer maximum temperatures for core rearing (summer rearing that occurs in the most important juvenile production areas. 61°F or 16°C) and non-core rearing and adult and juvenile migration (64°F or 18°C) are exceeded in the mainstem Middle Fork Willamette River below Dexter Dam. However, the altered temperatures have led to warmer water releases during fall, which leads to poor egg survival. In November, 1971, observers counted 219 spring Chinook redds in the first mile below Dexter, but many of the eggs were coated with fungus (ODFW 1990a).

Both average daily inflow and outflow temperatures reach the 52°F (11°C) threshold for upstream salmon migration in mid-May. A TMDL for the Willamette Basin was approved for temperature in 2006 (ODEQ 2006a). In this TMDL, ODEQ identified target temperatures for releases below Dexter/Lookout Point Dams, based on stream temperature inputs to the reservoirs and representing natural temperature regimes prior to dam construction (Table 4.2-4).

Month	Dexter/Lookout Point Release Temperatures	ODEQ Target for Dexter/ Lookout Point Releases
April	8.7	6.5
May	9.5	8.6
June	11.7	13.2
July	14.0	17.4
August	16.9	16.5
September	18.3	13.9
October	15.9	10.2
November	12.3	10.2

Table 4.2-4 Monthly Median seven-day rolling average temperatures downstream of Dexter/Lookout Point dams, and established ODEQ monthly target temperatures for salmon (ODEQ 2006a). No data presented for December through March; allocations/targets were not determined necessary for November through March.

As illustrated in Table 4.2-4 (above), the Dexter/Lookout Point dam complex modifies natural temperature patterns in downstream reaches. These modifications include colder summer water temperatures (June- July) and warmer fall water temperatures (September- October).

Water Temperature affected by Fall Creek Dam

Similar water temperature patterns have been observed below Fall Creek Dam as below Dexter Dam: water is cool in the spring and warm in the fall (USACE 2000). The ODEQ 2004/2006 Integrated Report database indicates exceedences of summer maximum temperatures for core cold-water habitat (rearing) (61°F; 16°C) above and below Fall Creek Dam. The USACE (2000) does not indicate when the crucial temperature of 52°F (11°C) for upstream migration is reached below Fall Creek Dam, and it is unclear from the information available in the ODEQ 2004/2006 database. Although there are no pre-project temperature data for Fall Creek Dam, it is still possible to consider temperature effects of the dams by using known temperature requirements for spring Chinook salmon. In the TMDL, ODEQ identified target temperatures for releases below Fall Creek Dam, based on stream temperatures inputs to the reservoirs and representing natural temperature regimes prior to dam construction (ODEQ 2006a, Table 4.2-5).

Month	Fall Creek Dam Release Temperatures	ODEQ Target for Fall Creek Dam Releases
April	7.5	6.5
May	11.3	8.6
June	14.0	12.2
July	17.2	15.9
August	16.6	15.8
September	9.8	13.5
October	12.9	10.6
November	10.8	10.6

Table 4.2-5 Monthly Median seven-day rolling average temperatures downstream of Fall Creek Dam, and established ODEQ monthly target temperatures for salmon (ODEQ 2006a, Chapter 4). No data presented for December through March; allocations/targets were not determined necessary for these months.

Water Temperature affected by Hills Creek Dam

Hills Creek Dam, located upstream of the Lookout Point/Dexter complex, influences water temperature in the mainstem Middle Fork Willamette between the dam and the head of Lookout Point Reservoir. Although effects decrease substantially downstream of Hills Creek Dam with the moderating effect of tributary inflow (USACE 2000), in general spring and summer (mid-April through mid-September) releases are cooler than inflow and fall and winter releases are warmer than inflow (USACE 2000, Figure 6-11). Data collected 13 miles below Hills Creek Dam, below the mouth of the North Fork Middle Fork Willamette, show that average water temperatures have been as much as 6°F (3.4°C) cooler than historically during the summer and as much as 4°F (2.2°C) warmer in the fall (USACE 2000, Figure 6-12). The ODEQ's 2004-2006 Integrated Report database[2] indicates exceedences of maximum temperature criteria for both cold water habitats (61°F; 16°C) and salmonid spawning (55°F; 13°C) in reaches above Hills Creek Reservoir. These temperature changes can delay upstream migration rates of the Chinook outplanted above Dexter/Lookout Point Dams and result in high egg mortality during incubation (similar to the results found below Dexter Dam mentioned above).

The target water temperatures below Hills Creek Dam identified in ODEQ's TMDL are compared to existing monthly temperatures in 4.2-6.

Table 4.2-6 Monthly Median seven-day rolling average temperatures downstream of Hills Creek Dam, and established ODEQ monthly target temperatures for salmon (ODEQ 2006a, Chapter 4). No data presented for December through March; allocations/targets were not determined necessary for November through March.

Month	Hills Creek Release Temperatures	ODEQ Target for Hills Creek Releases
April		5.8
May		7.8
June	7.9	11.0
July	8.6	14.2
August	11.0	13.6
September	16.0	12.5
October		9.6
November		9.6

Water Temperature Control & Site-Specific TMDL Requirements

Operating projects to optimize temperature conditions downstream for fish is often inconsistent with TMDL temperature targets, even with a temperature control tower such as the one constructed at Cougar Dam. Experience in implementing water temperature control operations in the Sound Fork McKenzie River downstream of Cougar Dam to achieve more normative water temperatures suggest that special site-specific considerations may be required for such actions with respect to achieving ODEQ TMDLs. An operational requirement for successfully avoiding high temperature discharges in the fall (i.e., during spring Chinook salmon incubation) is to evacuate as much warm surface water as possible from the reservoir throughout the summer months while operating within the range of appropriate downstream temperature criteria for each month identified by ODFW. That is, it is necessary to balance the effect of warm water temperatures downstream of the dam across the spring, summer and fall periods to achieve the

2 http://www.deq.state.or.us/wq/assessment/rpt0406/search.asp

most appropriate overall biological effect. In the South Fork McKenzie River, the requirement resulted in summer water temperatures below Cougar Dam that were will above the draft TMDLs identified by ODEQ during April through September (Figure 4.3-6) in order to provide more favorable temperatures during the critical incubation period in the fall. A focus on achieving the cooler TMDL temperature targets during summer would have adversely affected the temperature conditions achievable during the fall spawning and incubation period for spring Chinook because more warm surface water would have been retained in the reservoir over summer.

Water Temperature in Reaches above Project Dams and Reservoirs
The ODEQ 2004/2006 Integrated Report database indicates exceedences of maximum temperature criteria for both cold water habitats (61°F; 16°C) and salmon and steelhead spawning (55°F; 13°C) in reaches above the Willamette Project, including the upper Middle Fork Willamette above Hills Creek Reservoir; Salt Creek; the North Fork of the Middle Fork Willamette; Lost Creek; and Fall Creek above Fall Creek Reservoir. A TMDL for the Willamette Basin was approved for temperature in 2006 (ODEQ 2006a).

4.2.3.3.2 Total Dissolved Gas
Another important water quality parameter affected by the USACE dams is total dissolved gas (TDG). Releasing water from the dam spillways and regulating outlets can entrain atmospheric gasses, which can enter into solution at concentrations above the natural saturation level – termed total dissolved gas supersaturation. High TDG (above 120% saturation) can cause gas bubble trauma disease in fish and can cause mortality of eggs and juvenile fish if exposure is prolonged or acute. Monk et al. (1975) measured total dissolved gas levels of 104.9% (March 1972) to 125.5% of saturation (June 1970) within 0.3 miles below Dexter Dam and levels between 109.2% and 112.5% at sites 2.3 and 4.6 miles downstream (March 1972). USACE (1998) determined that dissolved gas levels were minimized when spilled water (1,200 to 8,000 cfs) was distributed across all of the spill gates. Total dissolved gas levels measured 2 miles downstream were generally less than 110% of saturation. Levels within the tailrace were 108.6% to 121.5% downstream of the turbine outlet works, and 107.3% to 119.0% downstream of spill gate number 7. Fish caught along the left bank (next to spill gate 7) and in the Dexter holding ponds during the study did not show signs of gas bubble disease (USACE 1998). Spring Chinook salmon yolk sac fry could be present below Dexter during March, but the USACE has not assessed the risk of gas bubble trauma at this location. Chinook spawning also occurs in the areas below Dexter Dam. It is unknown how the incubating eggs are affected by total dissolved gas, but since supersaturation has been reported downstream, it is likely eggs are affected.

4.2.3.4 Physical Habitat Characteristics

Generally, rearing UWR Chinook salmon use stream areas with large woody debris, gravel, and complex channel habitat. Spawning fish select redd sites with large gravel to cobble substrates and also benefit from channel complexity as complexity improves intragravel flows and the retention of suitable substrates. The general relationships between large wood, sediment transport, and channel complexity and the habitat requirements of UWR Chinook salmon are described in detail in Appendix A. Construction and operation of the USACE dams in the Middle Fork Willamette River subbasin has significantly impacted the quantity and quality of UWR Chinook habitat downstream from the dams; and, except for a small outplanting program, the dams have blocked access to more suitable upstream habitats. The large reservoirs behind the dams have inundated many miles of spring Chinook salmon spawning and rearing habitat in the watershed.

4.2.3.4.1 Habitat Conditions Downstream from Dexter, Lookout Point, & Hills Creek Dams

Following completion of the four Willamette Project dams in the Middle Fork Willamette basin, the amount of large wood in the stream channel has decreased, composition size of the substrate has increased on average, and stream beds have become channelized and less complex.

Substrate

Prior to the construction of Dexter, Lookout Point, and Hills Creek Dams, the lower Middle Fork Willamette River was described as having large areas of gravel bars and riffles with gravel and cobble substrates (USACE 2000). Parkhurst et al. (1950) noted that the lower river had an extensive floodplain with up to five different channels. The construction of the four USACE dams in the subbasin deprives lower Fall Creek and most of the mainstem Middle Fork Willamette River of sediment and large wood. Dexter-Lookout Point Dams and Hills Creek Dam, completed in 1954 and 1961, respectively, trap sediment and large wood from approximately 1,000 square miles. Fall Creek Dam, completed in 1966, traps sediment and large wood from nearly another 200 square miles. Together, these projects have reduced the area contributing sediment and large wood to the lower Middle Fork Willamette River by approximately 90%. The only remaining tributaries that contribute sediment and large wood are Little Fall Creek, a tributary to Fall Creek below the dam, and several small streams including Lost Creek. In the Middle Fork Willamette River below Hills Creek Dam and below Dexter Dam, the reduction in sediment supply has most likely resulted in substrate coarsening and channel downcutting. For example, ODFW has recently observed that the mouths of tributaries below the dams are perched above the Middle Fork Willamette channel, an indication of channel downcutting (USACE 2000).

Large Wood

Along the lower mainstem Middle Fork Willamette River, about 24% of the total length of the riparian corridor along the mainstem has high large wood recruitment potential, about 50% has moderate recruitment potential, and the remaining 26% has low recruitment potential (MFWWC 2002). Additionally, nearly half of the tributaries along the lower Middle Fork have low large wood recruitment potential, and only 25% are rated as having high large wood recruitment potential. Many riparian areas in the lower reaches of these drainages include non-native blackberry and other invasive weeds that prevent proper development of riparian forests, and many of the areas dominated by these species lack adequate stream shading.

Dykaar (2005) reviewed survey data from 1938 through 2004 in the lower mainstem Willamette River, and concluded that large woody debris jams have been nearly eliminated since the Project dams were constructed (Figure 4.2-9).

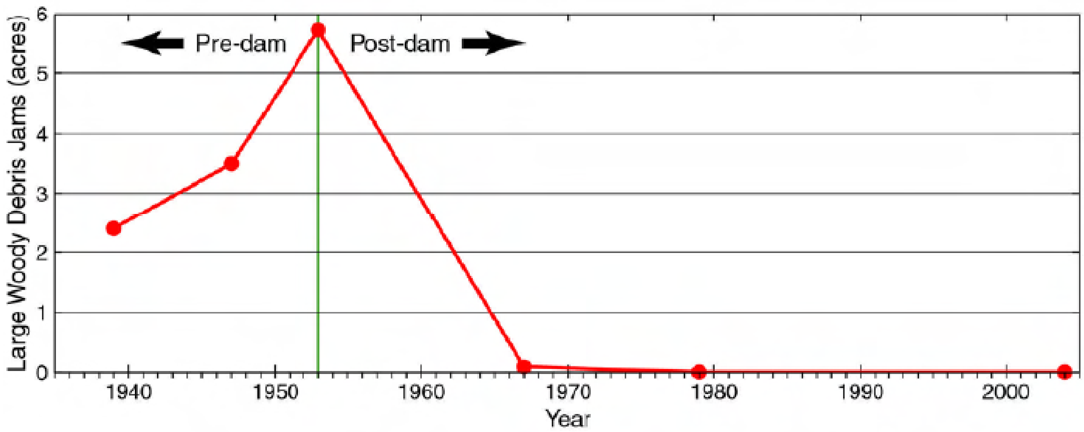


Figure 4.2-9 Observed large woody debris jams in lower Middle Fork Willamette. Source: Dykaar (2005).

Channel Complexity, Off-Channel Habitat, Floodplain Connectivity

Andrus and Walsh (2002) described changes in channel conditions in the lower Middle Fork Willamette River below Dexter Dam in the Eugene/Springfield area by air photo analysis. Overall, most of the reaches showed loss of sinuosity, side channel length, alcoves, and gravel bars, which indicates an overall loss of channel complexity in the lower river (Dykaar 2005, Figure 4.2-10). Gravel bar surface area decreased by 65%, and alcove length decreased by 35% (Table 4.2-7). Reduced gravel bar area reflects the dramatic reduction in channel-forming hydrologic events as a result of flood control in the Middle Fork Willamette. These gravel bars are colonized by riparian vegetation, which stabilizes the features and further inhibits movement and creation of new bars. Additionally, 50% of the lower 8 miles of the Middle Fork are protected by levees or revetments, which has likely increased the transport capacity of the river and facilitated further downcutting and floodplain isolation (USACE 2000).

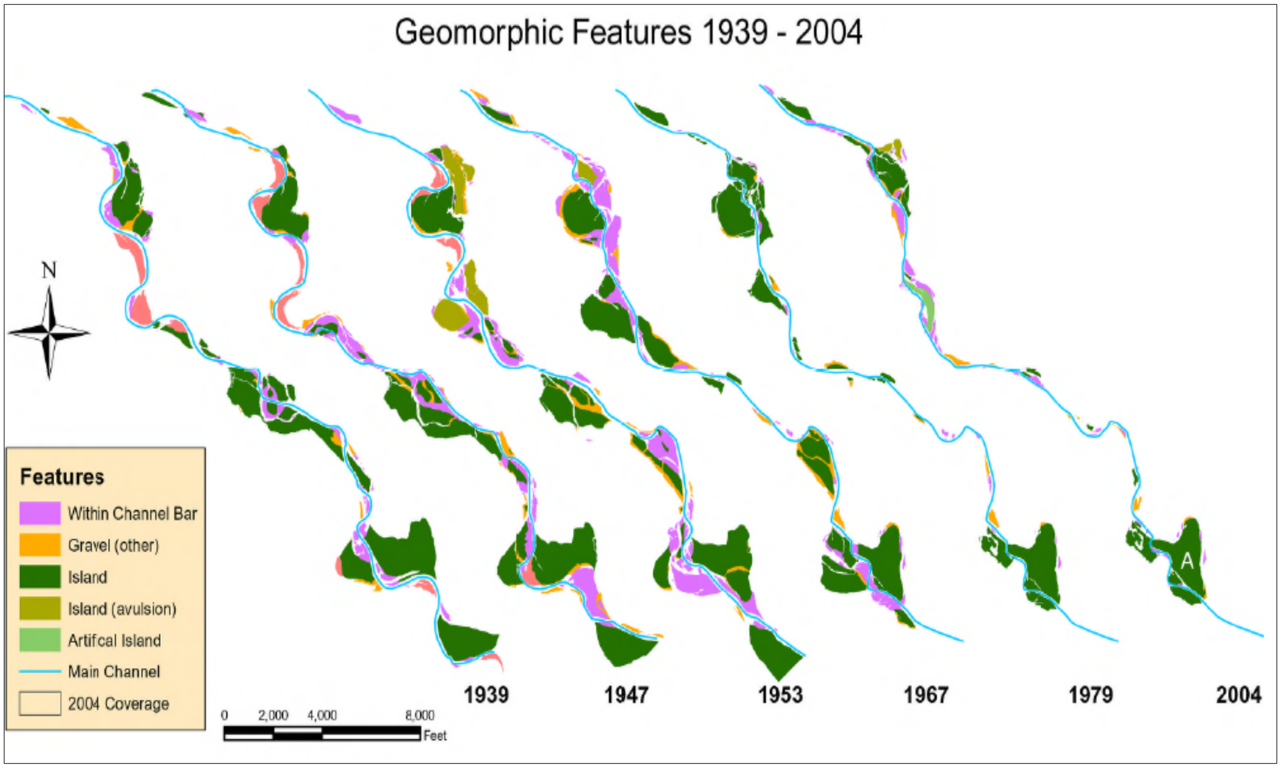


Figure 4.2-10 Middle Fork Willamette study reach below Dexter Dam. Figure: Dykaar (2005).

Table 4.2-7 Channel characteristics of the Middle Fork Willamette below Dexter Dam. Source: Dykaar (2005)

	Percent Change from a Pre-dam Average						
	Main Channel	Avulsion Rate		Total Gravel	Total Island	Rate of Island	Large Wood
River	Length	1st Order	2nd Order	Area	Area	Formation	Jams
Middle Fork	-10%	-100%	-95%	-70%	-57%	-91%	-100%
Coast Fork	-6%	-94%	-100%	-20%	-74%	NA	NA

Alcoves, side channels, and overall channel complexity have decreased significantly in the mainstem Middle Fork Willamette downstream of Dexter Dam, such that gravel bar area is only 35% of its extent in 1944. Due to peak flow reduction and sediment deprivation, it is likely that the bed material has coarsened downstream of Dexter Dam. The loss of complexity and coarsening of bed material could limit available spawning area downstream of Dexter, which could limit production in the Middle Fork, even if the temperature-related problems downstream of Dexter are resolved. Some spawning habitat is available in Fall Creek, but some areas have been scoured down to bedrock and while containing adequate resting pools, do not have a good supply of gravel and cobble, which could limit both spawning and rearing in the drainage. Half of the drainages within the upper Middle Fork drainage have embeddedness ratings that exceed the viable standards for salmonid spawning and incubation, which is 20% (WNF BRRD 1996), which could hinder spawning success if this habitat is made available to anadromous salmonids.

Willamette National Forest Lowell Ranger District (WNF LRD 1997) studied changes in the Middle Fork Willamette River channel in the five mile reach above Lookout Point Reservoir from 1944 to 1996. This reach is approximately 15 miles below Hills Creek Dam, which began operation in 1961. Aerial photos from 1944 indicate a sinuous, braided channel meandering across the valley bottom throughout most of this reach. Before the dam was built, the main channel and side channels shifted in response to floods that inundated the wide floodplain. After the dam was built, peak flows and bedload sediment delivery were reduced, grossly affecting the rate and nature of channel dynamics. This has resulted in the development of a single, simplified channel as old side channels have been abandoned and the river has lost its ability to create new side channels and other floodplain features (WNF LRD 1997).

4.2.3.5 Habitat Conditions in Reaches above Dexter, Lookout Point, and Hills Creek Dams

Land management and other activities over the last century in the Middle Fork Willamette watershed has reduced watershed function and degraded stream habitat. Above Dexter/Lookout dams (the lowermost dams), the watershed is predominately forested, federal land under the jurisdiction of the U.S. Forest Service-Willamette National Forest (WNF). Road building and timber harvest has been extensive in this area with associated adverse effects on stream habitat (Meehan and Bjornn 1991).

Substrate
Above the Project dams, sediment delivery and transport through streams is reflective of natural processes. These processes have been modified within some areas by wood removal or other activities, but a strong emphasis on aquatic conservation in the federally managed areas that predominate above the dams is anticipated to lead to more desirable conditions through time.

Large Wood
In many of the Middle Fork Willamette tributaries above Dexter and Lookout Point dams as well as the mainstem Fall Creek above Fall Creek Dam, large wood and pool levels are below Willamette National Forest (WNF) objectives, indicating that holding and rearing habitat quality is not ideal (WNF ORD 1995). The WNF initiated restoration efforts (in the form of large wood placement) in many tributaries which should facilitate habitat formation and maintenance.

Channel Complexity, Off-Channel Habitat, Floodplain Connectivity
In combination with watershed disturbance, flooding has also strongly affected channel characteristics in the Middle Fork watershed. For example, during the 1964 flood, landslides in tributaries of the Middle Fork, primarily associated with timber harvests and roads, contributed large quantities of sediment to the Middle Fork. As a result, the channel widened between 25% and 250%, with most channel widening and creation of side channels occurring near tributary junctions (Lyons and Beschta 1983). Large wood decreased following the 1964 flood, which Lyons and Beschta (1983) attribute to a combination of downstream transport, burial in sediment as the channel aggraded, and intentional salvage log removal. Since the 1970's, the channel has gradually narrowed as the aggraded alluvium was colonized by vegetation.
Riparian reserves and disturbance history

Riparian vegetation in the Middle Fork Willamette subbasin varies by drainage due to natural differences in geology, precipitation, elevation, and fire regimes, and by man-caused factors including: timber harvesting, road building, and land use.

Over 35% of riparian reserves in the upper Middle Fork drainage have been harvested, but over 41% remain in mature or old growth. The Swift Creek drainage has the least amount of mature riparian vegetation, but its headwaters contain some mature riparian vegetation located in the Diamond Peak Wilderness (WNF RRD 1996). Historically, nearly all riparian areas in the upper Middle Fork consisted of mature coniferous vegetation, but much has been replaced with either smaller-diameter or deciduous trees that do not perform the ecosystem functions described in Appendix A.

Although physical habitat characteristics in much of the Middle Fork's headwater streams is currently suboptimum, these streams are still functional and productive for salmon spawning and rearing and represent the best remaining habitat in the basin. The cooler, forested headwater habitat above Dexter/Lookout Dams is highly suitable for adult spring Chinook holding throughout the summer and spawning in the fall. Because these areas are predominately U.S. Forest Service land managed under the Aquatic Conservation Strategy of the Northwest Forest Plan, watershed processes are improving and these streams will continue to provide the best potential for providing quality habitat into the future.

Conclusion: Middle Fork Willamette habitat conditions in the baseline, especially in the reaches below Dexter and Fall Creek dams, are severely degraded. Large wood is depleted, decreasing the number of pools used for adult holding and juvenile rearing habitat. Channels have lost much of their complexity, decreasing the number of side channels normally used for juvenile rearing and refugia. Riparian vegetation has been modified, decreasing its value to salmon because the vegetation helps shade the streams and hold back sediment.

4.2.4 Hatchery Programs

Hatchery Chinook salmon were first released in the Middle Fork Willamette subbasin in 1919 (ODFW 1990a). Before 1950, two temporary collecting racks were set up in the Middle Fork each year, one about 2 miles above the town of Oakridge and the other 1 mile above the mouth of Salmon Creek (Mattson 1948; ODFW 1990a). Little is known about the contribution of hatchery releases to natural production during this period, but few adults are thought to have returned from releases made before the 1960s due to poor hatchery practices (Howell et al. 1985; ODFW 1990a).

The Willamette Hatchery was built to mitigate lost natural production of spring Chinook in the Middle Fork Willamette due to the construction and operation of Fall Creek, Dexter, Lookout Point, and Hills Creek dams and reservoirs. Since Fall Creek and Dexter Dams were completed and blocked upstream passage, hatchery broodstock has been collected at the base of the dams. It is likely the returns of wild Chinook declined precipitously shortly after the dams were built because more than 90% of their historic habitat was lost. Hatchery fish returns comprised a greater and greater proportion of the return to the Middle Fork Willamette. Presently nearly all of the Chinook are of hatchery-origin; although some natural-origin fish are still collected and passed upstream of Fall Creek Dam. Due to the significant temperature problems described above in section 4.2.3.3.1, successful natural reproduction below Dexter and Fall Creek dams is minimal by Chinook of either hatchery- or natural-origin. Hatchery fish represent nearly all of the spawners observed below Dexter and Fall Creek Dams.

The original hatchery program was initiated to support harvest in freshwater and ocean fisheries. However, following the listing of the species as threatened under the ESA, efforts began to transform the program into a conservation/supplementation role, due to the poor status of this population. The current hatchery program is being used to evaluate the potential for the reintroduction of Chinook to their historic habitat above the dams (USACE 2007a). Due to extremely poor natural reproduction and the dominance of hatchery-produced fish in the run, hatchery fish likely contain the only genetic remnants of the historic run available. These fish are the only remaining source of fish for outplanting efforts. The results of the outplanting program have been mixed (Beidler and Knapp 2005). Natural reproduction by hatchery fish has been observed in historic habitat upstream of the dams. However, prespawning mortality of the adults trapped at the base of the dams, trucked upstream, and released has been very high (see 4.2.3.1.1 for expanded explanation). This results in fewer successful redds in habitat above the dams, and is currently limiting the productivity of this outplanting program.

The hatchery program is also being reformed into an integrated broodstock, where the broodstock incorporates natural-origin fish on a regular basis so that the hatchery broodstock is as similar as possible to the natural-origin population. However, due to the extremely low numbers of natural-origin fish observed recently in this population, significant improvements are needed in the key and secondary limiting factors before this broodstock can be fully integrated. Recently, less than 1% of the broodstock has been natural-origin fish (Schroeder et al. 2006).

Hatchery programs in the Middle Fork Willamette continue to pose risks and some potential benefits to natural-origin Chinook salmon. Having all hatchery fish marked since 2001 has facilitated determining the status of natural-origin fish in this population. Hatchery fish will continue to represent the majority of natural spawners in this population until other limiting factors are addressed that allow natural production to increase.

4.2.5 Fisheries

UWR Chinook salmon returning to the Willamette River have supported many commercial and recreational fisheries, which contributed to their decline. In the past, harvest of natural-origin spring Chinook was permitted. However, recently fisheries management has focused on protecting natural-origin stocks, and more conservative fishing regimes have been implemented. In the past, cumulative harvest rates of spring Chinook salmon in ocean and freshwater fisheries have been high. Until recently spring Chinook salmon were subjected to relatively intense commercial and recreation fisheries in the lower Columbia and Willamette rivers that were directed primarily at the abundant hatchery-origin fish. Terminal area exploitation rates (the fishery impact to natural-origin fish) have been on the order of 40-50% in past years (Figure 4.2-11). Fishery objectives in the Willamette River have also changed to emphasize the protection of natural-origin fish. The State of Oregon developed a Fisheries Management and Evaluation Plan under NMFS' 4(d) Rule for the management of spring Chinook salmon fisheries in the Willamette River. This management plan specifies the harvest regime for spring Chinook salmon and has been approved by NMFS under the ESA. Total exploitation rates in commercial and sport fisheries occurring in freshwater are capped at 15%. However, fishery impacts since implementation of catch-and-release fisheries for wild spring Chinook have been in the range of

8-12% (Kern 2006). Impacts on natural-origin spring Chinook have been significantly reduced, yet the overall harvest of hatchery-origin fish has remained relatively high; emphasizing the benefits of selective fisheries to wild fish conservation and fishery harvest (Figure 4.2-12).

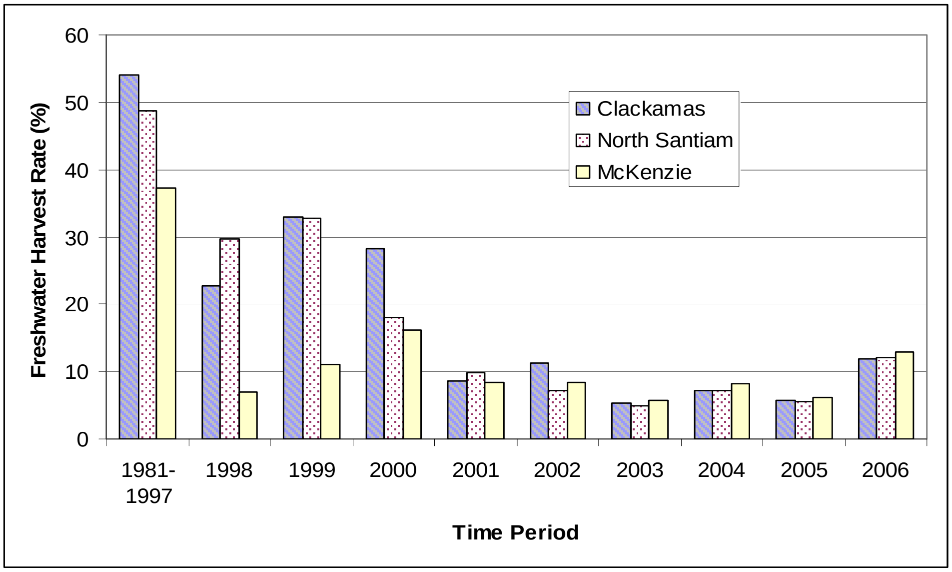


Figure 4.2-11 Exploitation rates of Willamette spring Chinook in freshwater commercial and sport fisheries. Data from Kern (2006).

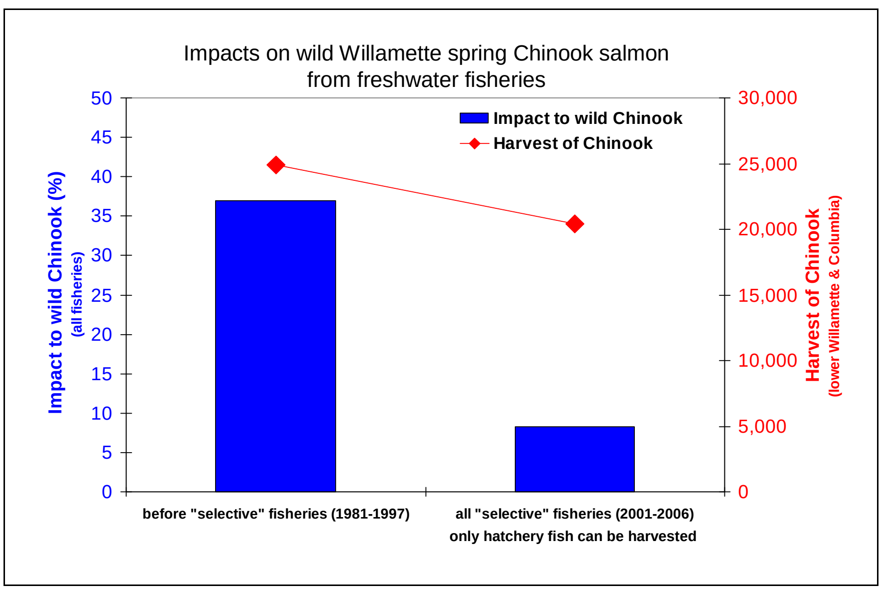


Figure 4.2-12 Freshwater fishery impacts and harvest of Willamette spring Chinook salmon before and after implementation of selective fisheries (where only adipose finclipped, hatchery Chinook can be retained). Data from Kern (2006).

Willamette spring Chinook salmon have a unique ocean distribution for a Columbia Basin spring Chinook stock. Willamette Chinook are a far north migrating stock and so are caught primarily in Southeast Alaska (SEAK) and North Coast British Columbia (NCBC) fisheries (Figure 4.2-

13). They return back to freshwater earlier than most other stocks and thus they tend to be missed by more southerly ocean fisheries off West Coast Vancouver Island, Washington and Oregon Coasts. The average exploitation rates of Willamette Chinook in ocean fisheries during the 1990's was 17%. The exploitation rates agreed to in the Pacific Salmon Treaty (PST) between the U.S. and Canada is 10-20%. However, the PST is being renegotiated and a new agreement expected in 2008.

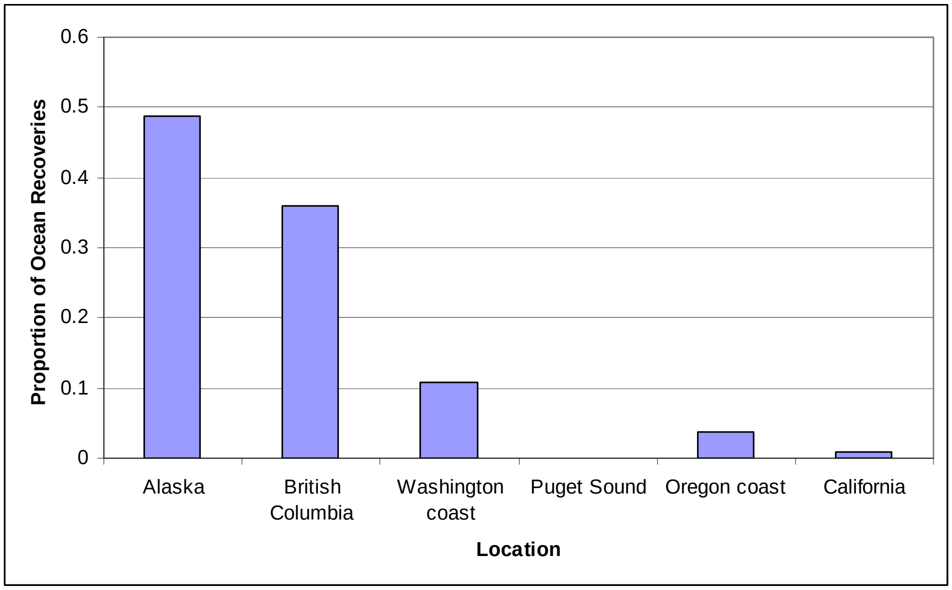


Figure 4.2-13 Distribution of Willamette spring Chinook salmon coded wire tag recoveries in ocean fisheries. Data from Myers et al. (2006).

Conclusion

Impacts of fisheries on natural-origin UWR Chinook salmon have been significantly reduced, yet the overall harvest of hatchery-origin fish has remained relatively high; emphasizing the benefits of selective fisheries to wild fish conservation and fishery harvest.

4.2.6 Status of PCEs of Designated Critical Habitat and Factors Affecting those PCEs in the Middle Fork Willamette Subbasin

NMFS has determined that the following occupied or potentially occupied areas of the Middle Fork Willamette subbasin either contain or do not contain Critical Habitat for UWR Chinook, as indicated (NMFS 2005d; maps are included in section 3.3 of this Opinion):

- Habitat of high or medium conservation value for these fish, and deemed important to their recovery, is present in 9 of the 10 watersheds within the Middle Fork subbasin (NMFS 2005g). In aggregate, these nine watersheds contain 166.1 miles of PCEs for spawning rearing, 98.8 miles of PCEs for rearing/migration, and 5.4 miles for migration/presence (NMFS 2005g). All nine of the watersheds containing these PCEs were designated as Critical Habitat (NMFS 2005d), as described below:
  - Seven watersheds (including Fall Creek) that are partly or entirely above USACE dams provide 138.1 miles of spawning/rearing habitat, 83.4 miles of rearing/ migration habitat, and 5.4 miles of migration habitat (NMFS 2005g). This includes 188 miles of Critical Habitat above USACE dams that is accessible to UWR Chinook only through experimental trap-and-haul programs. The blocked habitat (70% of that designated) historically produced over 90% of the Chinook salmon from this subbasin.
  - The Fall Creek watershed, which includes Fall Creek Dam on Fall Creek at Mile 7.0, contains 24.2 miles of spawning/rearing habitat, 14.1 miles of rearing/migration habitat, and 5.1 miles of migration/presence critical habitat (NMFS 2005g). Approximately 36.5 miles (84 %) of this habitat is above Fall Creek Dam.
  - Two watersheds that are as accessible to UWR Chinook today as they were historically, Lower Middle Fork Willamette and Little Fall Creek, contain 28.0 miles of spawning/rearing habitat and 15.4 miles of rearing/migration habitat (NMFS 2005g).
- The Salmon Creek watershed, which NMFS (2005g) identified as containing 2.8 miles of PCEs for spawning/rearing, was excluded from the critical habitat designation (NMFS 2005d), as described in section 3.3.

Bank protection measures associated with USACE activities total 30,742 linear feet (5.82 miles) of riverbank within the lower 8.5 miles of the Middle Fork Willamette River (USACE 2000). These measures all affect spawning/rearing habitats designated as Critical Habitat.

NMFS (2005g) identified the key management activities that affect these PCEs. Key management activities include forestry, dams, road building and maintenance, channel modifications/diking, dams, agriculture.

Four large-scale dams have been constructed in the Middle Fork subbasin: Dexter/Lookout Point, Hills Creek, and Fall Creek dams. Dexter/Lookout Point and Fall Creek dams blocked access to upstream spawning and rearing habitats representing over 90% of the historical production areas, reduced downstream migrant survival, altered flows downstream, reduced or eliminated marine-derived nutrients from these upper watersheds, and limited the downstream transport of habitat building blocks. These dams have negatively altered downstream water temperatures and habitat through the mainstem Middle Fork and Fall Creek below each dam since the 1960s. These dams have also adversely affected upstream habitats by inundation of over 30 miles of riverine habitats for the four reservoirs.

Table 4.2-8 summarizes the condition of PCEs within the Middle Fork Willamette River. Many of the habitat indicators are not in a condition suitable for salmon conservation. In most cases, this is primarily the result of the past operation and the continuing effects of the existence of the Project dams as well as the effects of other human activities (e.g., development, agriculture, and logging).

Table 4.2-8 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for the Middle Fork Willamette River Watershed under the environmental baseline.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Barriers Below Dexter and Fall Creek Dams* Canal to Springfield mill pond (N44.0263/W 122 9760), located 2.5 miles above confluence with Coast Fork. This dam no longer exists, but its canal still diverts water through an industrial area in Springfield with a mill pond, near South A street in Springfield.	Privately owned dams
Freshwater migration corridors	Habitat Access	Physical Barriers	*Fall Creek Dam as a Barrier to Upstream Migration* Most adult spring Chinook salmon and some winter steelhead trapped at Fall Creek Dam were trucked to McKenzie and other hatcheries; some released at a site two miles above head of reservoir Since 1998, all spring Chinook salmon returning to the collection facility have been released above the dam Upstream migrants could experience abrasion, mechanical injury, stress, migration delay, disease, and low dissolved oxygen concentrations in the trapping and transport facilities 77 (incl. 27 unmarked) spring Chinook were found dead at release site in August 2002 when large run overwhelmed the collection facility, leading to a clogged pipe in the fish transfer truck that resulted in dewatering the fish; USACE has since taken corrective action	USACE project (Fall Creek)

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Fall Creek Dam as a Barrier to Downstream Migration* Fish horn apertures on the upstream face of the dam were ineffective Chinook smolt recoveries never exceeded 15.6% and winter steelhead emigrated at even lower rates USACE passed smolts by draining the reservoir in the fall; 19 to 29% juvenile Chinook survival under this condition compared with 32% through the (mothballed) fish horn system (where most of the survivors had severe head and eye abrasions)	USACE project (Fall Creek)
Freshwater migration corridors	Habitat Access	Physical Barriers	*Dexter and Lookout Point dams as barriers to migration* Neither project built with fish passage facilities Upstream migrants trapped at Dexter are trucked to the Willamette Hatchery near Oakridge for spawning ODFW began releasing adult spring Chinook into the North Fork of the Middle Fork Willamette in 1999 and 2002, and into Salt Creek in 2001 The ODFW released Chinook fingerlings into the reservoir to augment the recreational trout fishery; 88% survival through turbines at Lookout Point Survival through the Kaplan turbines at Dexter unknown (may be similar to Foster Dam, 92%)	USACE project (Dexter/Lookout Point)

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Hills Creek Dam as a Barrier to Migration* Hills Creek built without fish passage facilities ODFW began releasing adult spring Chinook salmon above Hills Creek Reservoir in 1993 and has occasionally released hatchery-reared Chinook fingerlings into the reservoir 41% survival of juvenile Chinook through the turbines; 68% through the regulating outlet	USACE project (Hills Creek)
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base flow	Frequency of channel-forming flows not of sufficient magnitude to create and maintain channel complexity and provide nutrients, organic matter, and sediment inputs from floodplain areas Increased fall flows may allow spring Chinook to spawn in areas that will be dewatered during active flood control operations Winter and spring flow reductions may have reduce rearing area and the survival of steelhead fry Increased summer flows may increase rearing area and moderate naturally warmer water temperatures Low summer flows in specific reaches (due to diversions) may reduce the juvenile rearing habitat area, block adult passage to upstream spawning areas, and decrease the heat capacity of the stream Flow fluctuations now occur at rates rapid enough to entrap and strand juvenile anadromous fish.	Flood control operations at USACE's Fall Creek, Dexter/ Lookout Point, and Hills Creek dams reduce the magnitude and frequency of peak flows Fall releases from Fall Creek, Dexter/Lookout Point, and Hills Creek reservoirs Winter flood control and late winter and spring refill operations at USACE reservoirs Flow augmentation operations at USACE dams to meet mainstem flow targets Summer diversions for out-of-stream uses Power peaking at Hills Creek Dam Flood control operations at USACE's Fall Creek, Dexter/ Lookout Point, and Hills Creek dams cause rapid flow reductions

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Spring and summer releases from Hills Creek Dam are cooler than inflow; winter releases are warmer than inflow. This cool water delays UWR Chinook migration to spawning areas, and then warm water after spawning accelerates egg development, increasing egg mortality rates. Spring and summer releases from Fall Creek and Lookout Point/Dexter dams are cooler than inflow; fall/winter releases are warmer than inflow. The temperature of water flowing into Lookout Point Reservoir peaks at 62°F (16.7°C) in July, while outflow temperatures peak at 59°F (15°C) in September. The ODEQ 2004/2006 Integrated Report database indicates exceedences of summer maximum temperatures for core cold-water habitat (rearing) (61°F; 16°C) in Fall Creek. The ODEQ 2004/2006 Integrated Report database indicates exceedences of maximum temperature criteria for both cold water habitats (61°F; 16°C) and salmon and steelhead spawning (55°F; 13°C) in reaches that are not affected by Willamette Project flow management, including the upper Middle Fork Willamette above Hills Creek Reservoir; Salt Creek; the North Fork of the Middle Fork Willamette; Lost Creek; and Fall Creek above Fall Creek Reservoir.	USACE operations (Hills Creek) USACE operations (Lookout Point/Dexter, and Fall Creek) Timber harvest Clearing for floodplain development USACE operations (Hills Creek)

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	The ODEQ 2004/2006 Integrated Report database does not report any streams as water quality limited due to turbidity	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination Nutrients	The ODEQ 2004/2006 Integrated Report database does not indicate that any streams were water quality limited due to excess nutrients or toxics	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database indicates that Anthony and Lost creeks were water quality limited for dissolved oxygen year round for fish passage, spawning and rearing (ODEQ 2006b).	May be related to causes of elevated temperatures

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	TDG measurements up to 125.5% of saturation within 0.3 miles below Dexter Dam and up to 112.5% at sites 2.3 and 4.6 miles downstream. Spill over approximately 1,000 cfs through 1 spillway bay (there are 7 bays) at Dexter Dam generates more than 115% TDG below Dexter Dam.	USACE operations (Dexter Dam)
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool Frequency and Quality	Pool frequency and quality in the Middle Fork below Dexter Dam and Fall Creek below Fall Creek dam is low due to absence of pool forming elements such as LWD and sediment.	Downstream LWD and sediment transport blocked by project dams, roads, channel scour, land uses such as timber harvest, and diking in the lower river.
Freshwater spawning sites	Habitat Elements	Substrate	Substrate has coarsened in the Middle Fork downstream of Dexter Dam Channel downstream of USACE dams could lack spawning gravel USACE reservoirs block sediment into the lower Middle Fork from 90% of the Middle Fork subbasin Current sediment budget not creating and maintaining habitat needed by anadromous salmonids downstream of Dexter Dam	USACE reservoirs trap sediment and large wood from headwaters USACE operates Fall Creek, Hills Creek, Lookout Point, and Dexter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments Gravel mining

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	*In the mainstem Middle Fork* Large wood into the lower Middle Fork Willamette River is blocked from 90% of the subbasin The lower Middle Fork lacks large wood downstream of Dexter Dam	USACE remove large wood from reservoirs USACE removed snags in lower river for navigation Inadequate recruitment from riparian forests Removal of large wood by landowners and boaters for navigation and/or firewood
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	*In Tributaries and Upper Middle Fork Mainstem* Large wood does not meet USFS targets in most low-gradient upper Middle Fork tributaries, most of the North Fork Middle Fork drainage, Salmon Creek, Hills Creek, and the mainstem Fall Creek (WNF ORD 1995) Some large wood restoration efforts are underway in the upper subbasin (Salt Creek, Fall Creek) (WNF ORD 1995)	Timber harvesting Stream clean-out Fire suppression Constraint by roads Downstream LWD transport blocked by Project dams; historic removal of LWD and logjams

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Streambanks do not support natural floodplain function in the lower river.	Diking; residential and agricultural land uses; development; timber harvest; reservoir operations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Middle Fork Willamette River between Lookout Point and Hills Creek Dam is confined primarily to a single channel Gravel bar surface area has decreased by 65% below Lookout Point Dam 50% of lower 8 miles of the Middle Fork are protected by revetments Poor connectivity (generally absent or extremely limited) to off-channel habitat in lower river.	USACE operates Fall Creek, Hills Creek, Lookout Point, and Dexter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments USACE and EWEB remove large wood from reservoirs Gravel mining in lower river Diking, dredging, and human development.
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests The Middle Fork Willamette is disconnected from its historical floodplain by dikes and flood control operations that have reduced peak flows.	USACE operates Fall Creek, Hills Creek, Lookout Point, and Dexter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments Residential development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Disturbance History	Disturbance regime is dominated by timber harvesting Forests are dominated by early- to mid-successional stages, with few late-successional forests Timber harvesting has increased sediment delivery to streams, but decreased large wood input, resulting in degraded aquatic habitat Upper watershed is forested, but some is managed for timber production rather than ecosystem health Lower watershed is predominantly privately-owned, and while 65% of the lower watershed is managed for timber production, the remainder consists of agricultural, urban, and residential development	Fire suppression Timber harvesting Conversion to agricultural, urban, and rural uses

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	*Headwater forests riparian conditions* Riparian areas in some tributaries contain mature riparian vegetation (e.g., small tributaries of Lookout Point Reservoir, Fall Creek) but others (e.g., the North Fork Middle Fork Willamette, Salt Creek, Little Fall Creek, and small tributaries of the lower Middle Fork) are dominated by deciduous trees or conifers Many tributaries do not provide adequate shading or large wood recruitment Decreased extent of streamside riparian vegetation *Floodplain forest riparian conditions* Many remaining patches of floodplain forest are interspersed with pastureland, highways, and residential development Floodplain forests along lower river invaded by non-native species that hinder development of natural community 74% of riparian forests along lower Middle Fork have low or medium large wood recruitment potential. Decreased surface area of gravel bars for potential young riparian stand recruitment	Timber harvesting Stream clean-out practices Extensive inundation of streamside riparian vegetation by USACE reservoir construction Clearing for agriculture or development USACE and private revetments USACE's operation of Fall Creek, Hills Creek, Lookout Point, and Dexter Dams alters the hydrologic regime Timber harvest

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Section 4.3
McKenzie Baseline

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4.3 The McKenzie Subbasin

The McKenzie River is approximately 90 miles long and drains an area of about 1,340 square miles (Figure 4.3-1). Moving downstream from groundwater-fed headwaters associated with porous volcanic landforms high in the Cascades, the river's major tributaries include Horse Creek at about RM 67, the South Fork McKenzie (RM 59), Blue River (RM 57), and Mohawk River (RM 14). Much of the subbasin is mountainous, though there are flat bottomlands along the lower McKenzie and the Mohawk River. About 70% of the subbasin is federal forestland, with the Willamette National Forest accounting for nearly the entire area above the Blue River confluence except for private in-holdings near the main McKenzie. Forested tributaries to the McKenzie below Blue River, and particularly below Vida (at RM 41), have mixed to strongly private ownership as the river flows to and through Willamette Valley bottom-lands that begin near Deerhorn Bridge at RM 32. Much of the valley floor below this bridge has been converted to agriculture or put to residential use (MWC 1996).

The McKenzie River channel decreases in slope from about 1.2% above Belknap Springs (near RM 75) to less than 0.4% through a glacial valley above Blue River, to less than 0.2 % when the river enters the Willamette Valley (USACE 2000). High dams affecting the river include those in the Carmen-Smith Hydroelectric Project (above and including Trail Bridge Dam near RM 82), and two USACE structures: Cougar Dam at Mile 4.2 on the South Fork McKenzie and Blue River Dam at RM 1.3 on Blue River. A small, ladder-equipped dam on the McKenzie at approximately RM 29 (Leaburg Dam) diverts water into a power canal as part of the Leaburg-Walterville Hydroelectric Project.

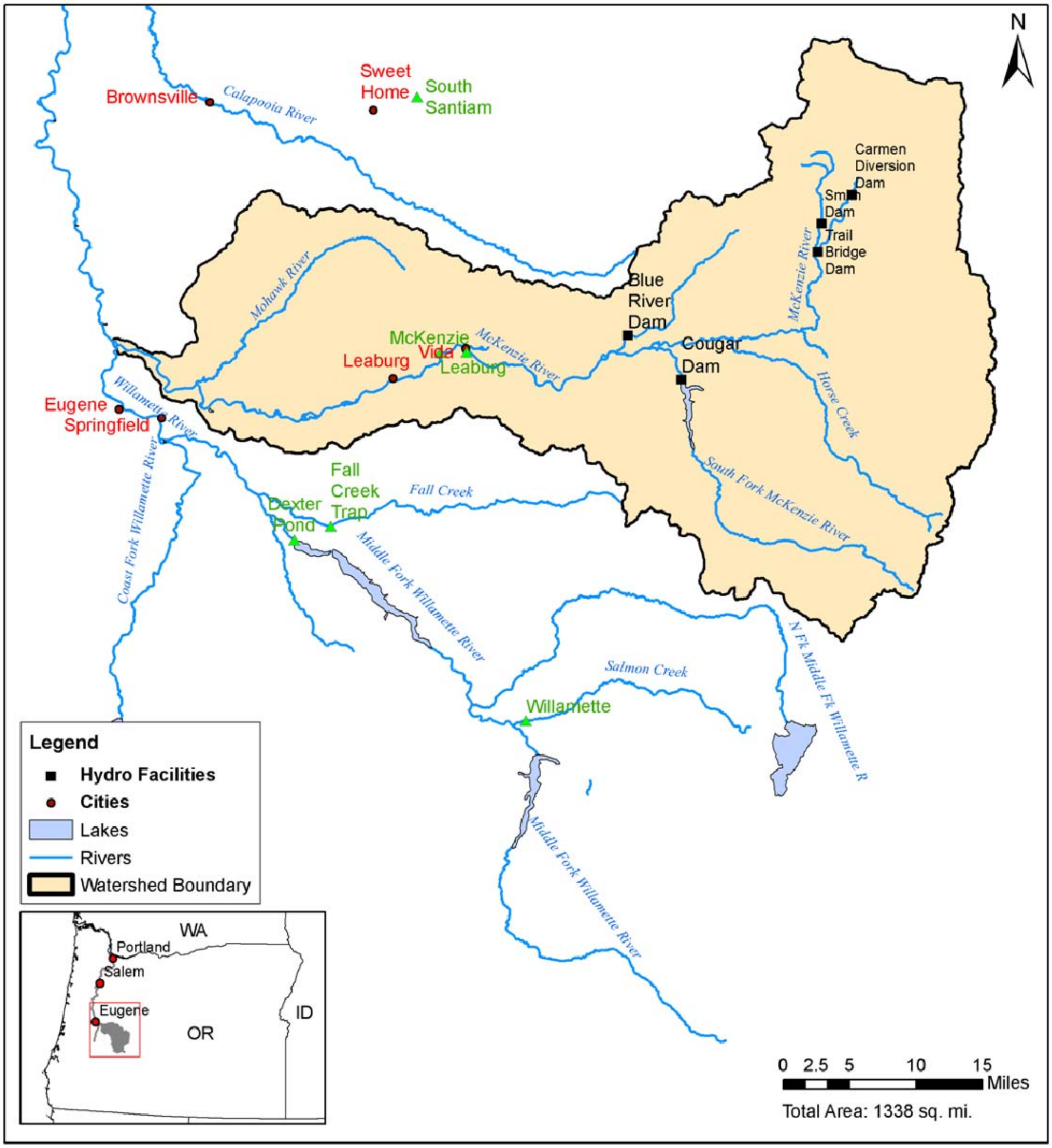
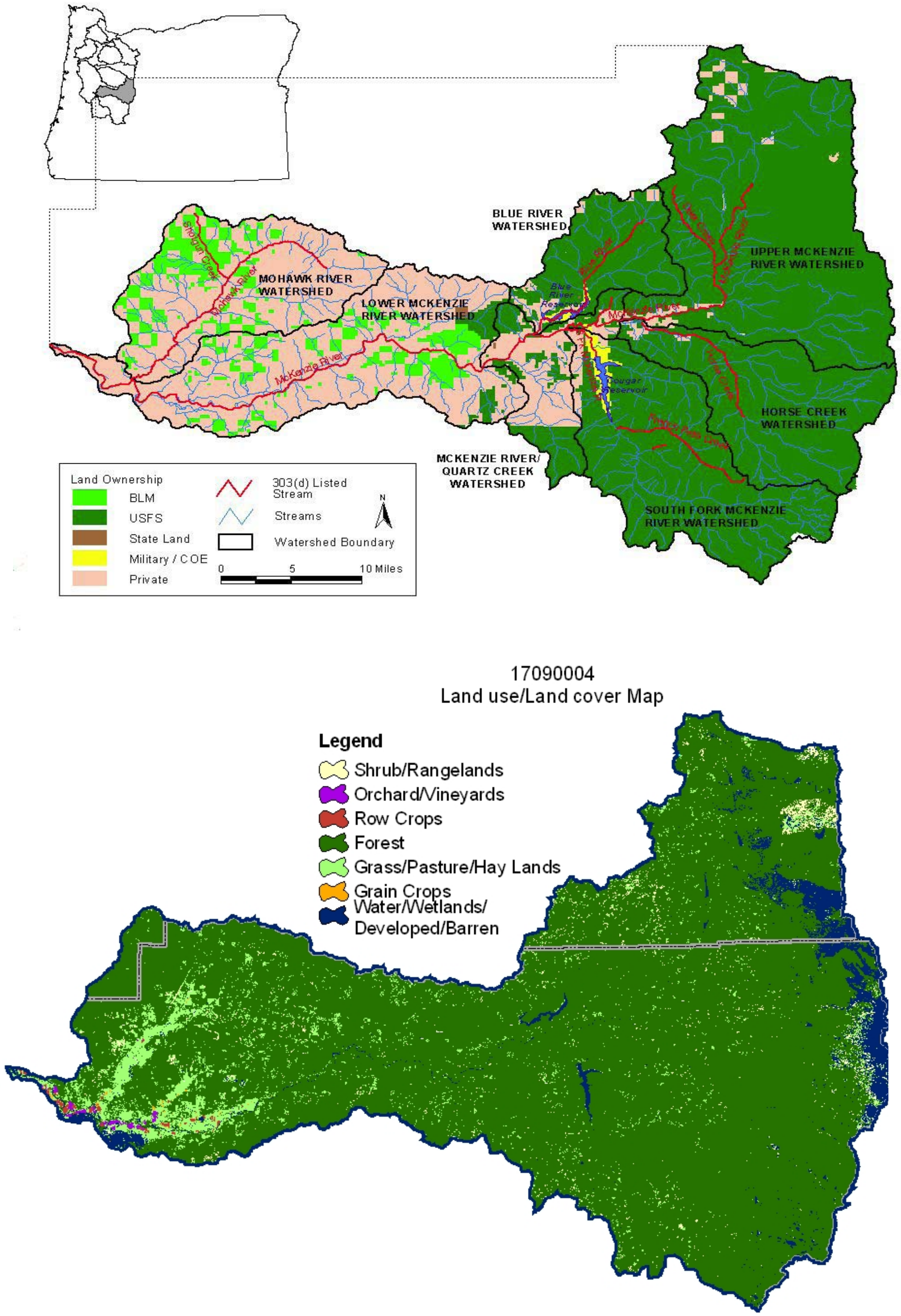


Figure 4.3-1 Map of the McKenzie subbasin



Figures 4.3-1 Maps of the McKenzie subbasin (ODEQ 2006a, top) and of land use patterns within the subbasin (NRCS 2006b, bottom).

4.3.1 Historical Populations of Anadromous Salmonids in the McKenzie Subbasin

4.3.1.1 UWR Chinook Salmon

Historical spawning areas for UWR Chinook within the McKenzie subbasin included the mainstem McKenzie River, Smith River, Lost Creek, Horse Creek, the South Fork, Blue River, Gate Creek, and Mohawk River (Mattson 1948, Parkhurst et al. 1950). Habitat that remained suitable for, and available to, these fish in the 1940s was estimated to have the capacity to support about 80,000 spawners (Parkhurst et al. 1950). However, adult runs this large were never documented. The Oregon Fish Commission estimated that the largest run of UWR Chinook salmon into the McKenzie River subbasin for which it had data was one of about 46,000 adults in 1941. This estimate was based on an assumption that 39 percent of the UWR Chinook salmon adults counted passing over Willamette Falls were bound for the McKenzie subbasin (Mattson 1948, USACE 1995). Estimated run sizes of UWR Chinook returning to the McKenzie subbasin from 1945-1960 averaged 18,000 adults (USACE 1995). A run of 4,300 adult Chinook escaped to spawn in the South Fork alone in 1958 (USFWS 1959).

4.3.1.2 UWR Steelhead

UWR steelhead are sometimes found within lower elevation areas of the McKenzie subbasin, but these areas are not thought to have supported a historical population of the species.

4.3.2 Current Status of ESA-Listed Anadromous Salmonids within the Subbasin

4.3.2.1 UWR Chinook Salmon

Population Viability

The latest status assessment of UWR Chinook salmon, by McElhany et al. (2007), rated the McKenzie population as being at moderate risk of extinction based on an evaluation of its abundance, productivity, spatial structure, and diversity. Within-subbasin contributors to this risk include habitat degradation associated with USACE dams, land use, and the ecological and genetic effects of a very large fish hatchery program within the subbasin. Potentially catastrophic events that could unfavorably affect the population include landslides, hatchery-related disease epidemics, and pollution discharges from roadway/transportation spills (WLCTRT 2003).

Abundance & Productivity (A&P)

McElhany et al. (2007) classified the UWR Chinook population in the McKenzie subbasin as facing a moderate extinction risk based on its abundance and productivity, with a modest level of uncertainty. The population was once one of, if not the largest within the Willamette Basin, but now has greatly reduced numbers of spawning adults. McElhany et al. (2007) estimated the spawning population's long-term (1970-2005) geometric mean abundance as 1,655 natural-origin spawners, its short-term (1990-2005) geometric mean abundance as 2,104.

Adult UWR Chinook returning to the McKenzie River are counted as they pass over Leaburg Dam and surveys are conducted in the natural spawning areas of these fish both above and below this dam. Figure 4.3-2 gives the numbers of wild (natural-origin) and all (wild plus hatchery-origin) adult Chinook estimated to have passed Leaburg Dam each year from 1970 through 2006. Estimates of the wild component of the run were relatively uncertain until 2001, when expanded hatchery fish marking and monitoring programs enabled accurate discrimination of wild fish. Annual numbers of wild adult Chinook passing Leaburg Dam during the most recent 5-year period for which data are available (2002-2006) ranged from a high of 4,899 fish in 2003 to a low of 2,189 fish in 2006, and averaged 3,509 fish (McLaughlin et al. 2008). The number of wild adults passing the dam in 2003 was similar in magnitude to the largest estimates of wild fish escapement over the dam since 1970.

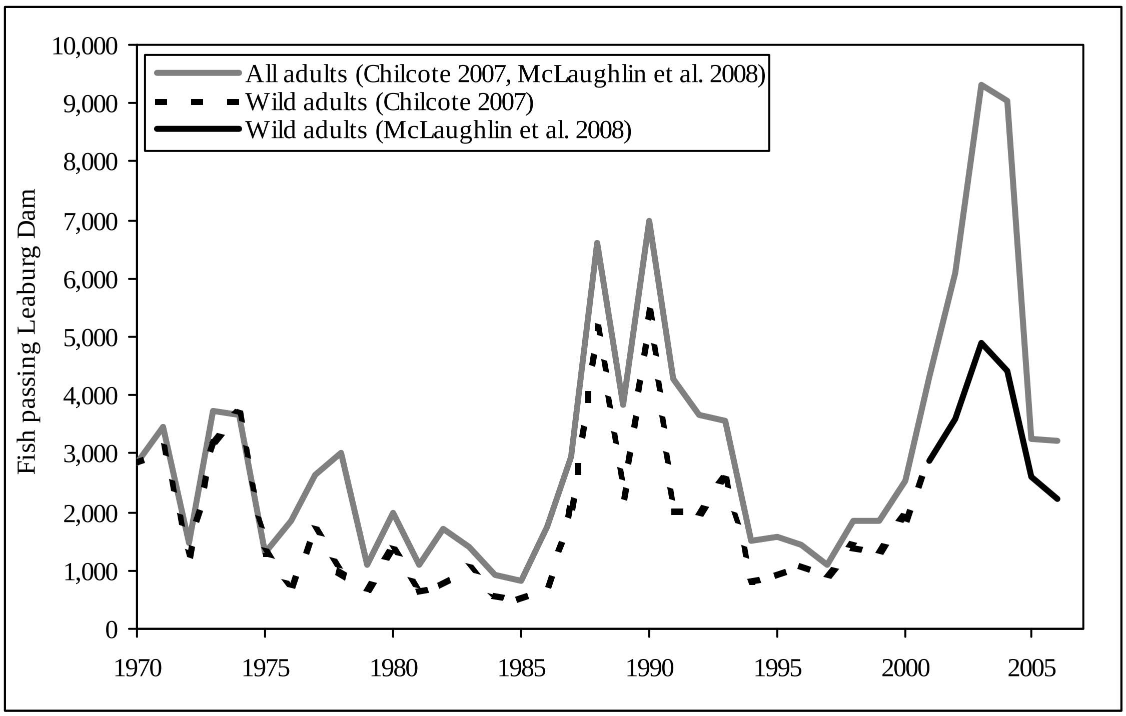


Figure 4.3-2 Estimated annual number of wild and all (wild and hatchery-origin) adult spring Chinook salmon passing above Leaburg Dam on the McKenzie River, Oregon, 1970-2006. Data sources: Chilcote (2007) and McLaughlin et al. (2008).

Hatchery-origin fish continue to pass Leaburg Dam and enter the natural spawning areas of McKenzie spring Chinook above the dam, posing a potential risk to the productivity of the naturally spawning population (Table 4.3-1). McLaughlin et al. (2008) have, for Chinook runs since 2001, developed two sets of estimates of the annual percentage of adults passing above the dam that were of hatchery-origin. One set is based on straight dam counts and the other has an adjustment for what is thought to be fall-back (false passage) of hatchery-origin fish. Dam counts unadjusted for fall-back suggest that the annual percentages of hatchery-origin adults upstream of Leaburg Dam have ranged from 21% to 51%, and averaged 38% during the last 5 years (McLaughlin et al. 2008). The adjusted counts suggest lower percentages of hatchery fish above the dam, ranging from 17% to 39%, and averaging 30% during the last 5 years, and are thought to provide a better indication of the proportion of hatchery fish in the naturally spawning population (McLaughlin et al. 2008).

Table 4.3-1 Estimated number of adult spring Chinook salmon of natural (wild) and hatchery origin passing upstream of Leaburg Dam, 2001-2005, as determined by analyses of otoliths in non fin-clipped fish and coded wire tags in fin-clipped fish (McLaughlin et al. 2008).

Year	Wild adults (natural-origin)	Adults of hatchery origin	Total	Percent hatchery-origin adults*
2001	2,880	1,422	4,302	33 (32)
2002	3,602	2,485	6,087	41 (35)
2003	4,899	4,428	9,327	47 (39)
2004	4,419	4,615	9,034	51 (39)
2005	2,435	659	3,094	21 (18)
2006	2,189	981	3,170	31(17)
5-year average (2002-2006)	3,509	2,634	6,143	38 (30)

* Percent hatchery values given in parentheses are intended to provide an adjustment for what appears to be dam fall-back of non-clipped fish.

The distribution of hatchery-origin Chinook spawners among natural spawning areas within the McKenzie subbasin is far from uniform and suggests that certain components of the population may be somewhat less affected by whatever influence stray hatchery spawners have on the productivity of wild fish. During 2001-2004, Schroeder et al. (2005) found lower proportions of hatchery-origin spawners in carcasses recovered in the mainstem upstream of a point near the South Fork confluence (Forest Glen) and in Lost and Horse creeks than were found in the South Fork or areas downstream. Hatchery spawners constituted a particularly high fraction of spawners in the lower McKenzie below Leaburg Dam (Schroeder et al. 2005).

Carcass recoveries from Chinook spawning areas suggest that rates of pre-spawn mortality above Leaburg Dam are relatively low compared to those seen for UWR Chinook in other spawning areas within the Willamette Basin. From 2001 through 2006, carcass recoveries above the dam suggest annual pre-spawn mortality rates ranging from 1% to 16%, and averaging 9%.

Spatial Structure

McElhany et al. (2007) rate the spatial structure of McKenzie spring Chinook salmon as characteristic of a population having a low to moderate risk of extinction. ODFW (2005b) estimates that 16% of the population's historical habitat has been blocked by dams. Cougar Dam now blocks access to most of the productive South Fork watershed, and Blue River Dam and the Carmen-Smith hydroelectric project block smaller amounts of habitat. High quality habitats remain accessible in significant portions of the subbasin not blocked by dams, but habitat degradation apparently extirpated a spawning aggregate in the Mohawk watershed a century ago (Parkhurst et al. 1950) and historically-significant rearing habitat in the upper Willamette River mainstem has been lost or damaged.

Diversity

McElhany et al. (2007) rated the diversity of the McKenzie population of UWR Chinook as reflecting a moderately high risk of extinction, based on an examination of available information on life history traits, effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity. Key concerns in this regard were the genetic influences of the large hatchery program in the basin and the effects of altered thermal regimes below the USACE dams on fish life-histories.

4.3.2.2 UWR Steelhead

UWR Steelhead are sometimes found within lower elevation areas of the McKenzie subbasin, but these areas are not thought to have supported a historical population of the species.

4.3.2.3 Limiting Factors & Threats to Recovery

Factors within the McKenzie subbasin that are unfavorably affecting the status of its population of UWR Chinook have been summarized by ODFW (2007b) and are given in Table 4.3-2. Key limiting factors and threats to the species within the subbasin include a variety of dam effects, a large hatchery program developed partly to help offset dam effects, and the cumulative effects of multiple land and water use practices on aquatic habitat. Dams that lack effective passage facilities prevent wild fish from using historically important habitats on Federal lands in upper portions of the McKenzie subbasin, particularly above Cougar Dam on the South Fork McKenzie River. Habitat changes along the mainstem Willamette River and in the Columbia River estuary some related to the Willamette Project dams or to other USACE programs, also limit the populations.

In all, 2 of 4 primary limitations and 2 of 6 secondary limitations on the recovery of the McKenzie's ESA-listed population of UWR Chinook are related to USACE dams or programs (ODFW 2007b, Table 4.3-2). Even though the limiting factors and threats are broken into two groups, the secondary factors are important to address as well as the key factors.

Table 4.3-2 Key and secondary within-subbasin limiting factors and threats to recovery of McKenzie Spring Chinook (source: ODFW 2007b).

<table>
<tr><th rowspan="2">Threats</th><th rowspan="2">Species</th><th colspan="8">McKenzie Subbasin
(Streams and Rivers within Population Area)</th></tr>
<tr><th>Egg</th><th>Alevin</th><th>Fry</th><th>Summer Parr</th><th>Winter Parr</th><th>Smolt</th><th>Adult</th><th>Spawner</th></tr>
<tr><td>Harvest</td><td>Chinook</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Hatchery</td><td rowspan="3">Chinook</td><td rowspan="3"></td><td rowspan="3"></td><td colspan="3">4b</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">3</td></tr>
<tr><td colspan="3">6c</td></tr>
<tr><td colspan="3">6d</td></tr>
<tr><td>Hydropower/ Flood Control</td><td>Chinook</td><td colspan="2">9g</td><td colspan="3">10d</td><td></td><td>2d</td><td>7e</td></tr>
<tr><td rowspan="2">Landuse</td><td rowspan="2">Chinook</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">8a</td><td>8a</td><td rowspan="2">8a</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>9a</td></tr>
<tr><td>Introduced Species</td><td>Chinook</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Black cells indicate key concerns; Gray cells indicate secondary concerns.

Key threats and limiting factors

2d Impaired access to habitat above McKenzie hydropower/flood control dams.
3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
8a Impaired physical habitat from past and/or present land use practices.
10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Secondary threats and limiting factors

4b Competition with naturally produced progeny of hatchery spring Chinook.
6c Predation by hatchery summer steelhead smolts.
6d Predation by hatchery rainbow.
7e Lack of gravel recruitment below McKenzie hydropower/flood control dams due to gravel capture in upstream reservoirs.
8a Impaired physical habitat from past and/or present land use practices.
9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
9g Elevated water temperatures below McKenzie hydropower/flood control dams resulting in premature hatching and emergence[1].

[1] Cougar water temperature control tower addressed temperature in South Fork McKenzie and most of the mainstem McKenzie River.

4.3.3 Environmental Conditions

4.3.3.1 Habitat Access

General relationships between safe passage and access to historical habitat and the habitat requirements of UWR Chinook salmon are described in Appendix E. Table 4.3-4 summarizes the status of safe passage and access to historical habitat in the McKenzie subbasin under the environmental baseline, which is described in more detail below.

There are currently five dams in the McKenzie River Subbasin that affect anadromous fish. The USACE owns two of these dams: Cougar Dam on the South Fork McKenzie River, and Blue River Dam on the Blue River. The three other dams are owned and operated by Eugene Water and Electric Board (EWEB): Leaburg Dam on the mainstem McKenzie River, Trail Bridge Dam on the mainstem McKenzie near the headwaters, and Smith Dam at Mile 2.1 on Smith River, above Trail Bridge Dam. EWEB also operates the Walterville Canal (at RM 28.5) and Powerhouse (RM 20.9), and the Leaburg Canal (RM 38.8) and Powerhouse (RM 33.3), all located adjacent to the mainstem McKenzie River on the right bank.

Up- and downstream fish passage conditions at the facilities just identified vary from meeting modern standards of effectiveness to being inadequate to sustain migratory fish populations that would otherwise depend on such passage. Passage conditions at Cougar and Blue River dams are of the latter type, with those at Cougar severely affecting natural salmon production in what was once the McKenzie river tributary most heavily used by UWR Chinook.

4.3.3.1.1 Fish Passage at Leaburg & Walterville Hydroelectric Projects

For many years, adult Chinook salmon were delayed in the tailraces of EWEB's Leaburg and Walterville powerhouses. Under the terms of EWEB's renewed FERC license (NMFS and USFWS 2001), the construction of tailrace barriers during 2003 has reduced the likelihood of attraction and delay. Delay was further reduced at Leaburg Dam in 2004 by modifying the left-bank fish ladder and redesigning and reconstructing the right-bank fish ladder to meet current design criteria.

The terms of EWEB's new FERC license also included improvements for downstream fish passage. Construction of a new screen at the entrance to the Walterville Canal and reconstruction of the existing screens at the Leaburg canal, and associated bypass systems, have reduced passage mortality of downstream migrating Chinook salmon to less than 0.5%. The Walterville screens were completed in 2002, and the Leaburg screens were completed in 2004.

Similarly, recent changes in instream flow requirements for the mainstem McKenzie River at these projects have benefited migrating fish. Prior to 1991, EWEB's diversions into the power canals left as little as 465 cfs in the bypassed mainstem reach at Leaburg and as little as 350 cfs at Walterville, affecting migration conditions (habitat availability and instream temperatures) for migrating juvenile and adult Chinook salmon. As a requirement of its new FERC license, EWEB now maintains instantaneous minimum flows immediately downstream of Leaburg Dam and at the Walterville intake at 1,000 cfs.

4.3.3.1.2 Fish Passage at Trail Bridge & Smith Dams

At the upper end of the mainstem McKenzie River, EWEB's Trail Bridge and Smith dams exclude spring Chinook salmon from a portion of their historical range (about 8 miles) because neither dam was built with fish passage facilities. As mitigation for the lost habitats, EWEB constructed a spawning channel below Trail Bridge Dam when the dam was constructed. The spawning channel was originally designed to accommodate a minimum of 200 spawning Chinook (100 pairs), which is the estimated number of fish that historically spawned in the areas above Trail Bridge Dam. Chinook spawn in the channel annually, but numbers of returning Chinook have generally been below 200 fish until recent years. It is unclear if the increases were due to increased ocean survival, returns of progeny from ODFW outplants of adult hatchery Chinook above Trail Bridge, or a combination of both factors.

In 2006, EWEB filed a license application with FERC to relicense the Carmen Smith Hydroelectric Project, which includes Trail Bridge and Smith Dams. EWEB's proposed action included providing both up- and downstream passage facilities at Trail Bridge Dam. Once these facilities are constructed, UWR Chinook salmon would be able to access about 8 miles of historic spawning and rearing habitat.

4.3.3.1.3 Fish Passage at Cougar Dam

Cougar Dam was built in 1963 with adult and juvenile fish passage facilities that ultimately proved incapable of maintaining what was once a very large run of spring Chinook salmon into the 56 km of spawning and rearing habitat found in the South Fork McKenzie watershed above the dam. The dam will prevent recovery of the salmon production potential of this watershed unless or until effective fish passage is provided.

Upstream Passage

Adult salmon were initially trapped at a collection facility in the tailrace and trucked upstream to a release point near the head of the reservoir. The system was evaluated in a 4-year study, beginning in 1964, by the Oregon Fish Commission. After the first 2 years, serious problems were evident. Adult spring Chinook salmon entered the permanent trap in the tailrace channel in August and September rather than as expected in June and July (Ingram and Korn 1969). Ingram and Korn observed that many fish were attracted to the surface water discharged through the regulating outlet, and, in an attempt to collect those fish, ODFW built a temporary trap into the weir at the downstream end of the regulating outlet channel. When both traps were operating, the trap in the RO channel collected virtually all of the fish. Ingram and Korn concluded that the poor return of adults to Cougar Dam was related to the temperature of water in the tailrace, which was 10°F (5.6°C) cooler than in the RO channel. The original fish trap was judged a failure and last used to collect adult spring Chinook salmon for transfer to areas above Cougar Dam in 1966.

In 2009, USACE will construct a new fish trapping facility for collecting adult Chinook salmon and other species at the base of Cougar Dam and hauling them to upstream release sites. Although NMFS completed consultation on trap construction (NMFS 2007a), the Action Agencies included the continued operation of the facility as part of the larger Proposed Action that is the subject of this consultation. Hence, only the construction of the new trap, not its operation is part of the baseline for this consultation.

Downstream Passage

The original downstream passage system for juvenile fish at Cougar was intended to collect fish through one of five horns[2] incorporated into the dam's water intake tower. Like the upstream passage system, it did not work as well as envisioned. Ingram and Korn (1969) found that the fish horns collected only a low percentage of the juvenile Chinook available in the reservoir and many of those collected were injured or killed. An estimated 28.2% of the test fish (marked hatchery yearling Chinook) that Ingram and Korn released into the South Fork above the reservoir during the spring of 1965 emigrated downstream and 21.1% in 1966. Two test groups released into the forebay in 1966 emigrated at rates of 22.5% and 21.0%, respectively. One of the reasons for poor emigration may have been that the operating collection horn was under a considerable depth of water (10 to 45 feet) during much of the test period; whereas gill net catches showed that Chinook were distributed mainly in the upper 15 feet of the forebay at that time (Ingram and Korn 1969). Of the total numbers of wild fish collected at the downstream evaluator, dead fish constituted 40% in 1965, 30% in 1966, and 28% in 1967. Many of the live fish in the evaluator were seriously injured, and Ingram and Korn (1969) suggested that extensive delayed mortality may have occurred. Based on their data, Ingram and Korn judged that the juvenile passage facilities at Cougar Dam, like those for adult passage, were inadequate.

ODFW began releasing hatchery-reared fingerling Chinook into Cougar Reservoir in 1963, to augment the recreational trout fishery (Mamoyac and Ziller 2001), and then started releasing hatchery-origin adult Chinook above Cougar Dam in 1993 to restore inputs of marine-derived nutrients and a prey base for bull trout in the upper South Fork watershed. ODFW originally assumed that most of the juvenile salmon produced by these adults would be killed during passage through the turbines or regulating outlet if they tried to leave the reservoir. However, between 1994 and 1997, field observations provided circumstantial evidence that some juveniles were surviving passage (Taylor 2000). During the first year of a 2-year passage survival study (November 1998 through March 1999), approximately 14,000 juvenile Chinook migrated through the regulating outlet (67.4% survival) and about 1,500 to 3,900 through the turbines (92.9% survival; Taylor 2000). Turbine survival was 81.9% during the second year of study (1999 through 2000), which may have been due to a 2-cm increase in smolt size compared to the previous year (survival appeared to decrease with increasing fish size and may have been as low as 50% for fish >20 cm in length). Taylor (2000) could not determine why survival was lower through the regulating outlet than through the turbines.

Outplant Program above Cougar Dam

ODFW's hatchery adult outplanting program in the upper South Fork watershed has expanded in the last several years to include consideration of re-establishing natural use of habitat above Cougar Dam to aid recovery of UWR Chinook salmon. Releases of adult Chinook above Cougar Dam that have been made as part of this program are included in Table 4.3-3. Limited evaluations of the program suggest that adult Chinook are spawning successfully and producing juvenile fish above the dam (Beidler and Knapp 2005). Pre-spawn mortality of released adults

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[2] A "fish horn" (or "reduced velocity fish entrance port") is a loudspeaker-shaped aperture on the upstream face of a dam. At Cougar, five fish horns are spaced 39.5 feet apart down the upstream face (Ingram and Korn 1969). Each horn is 20 feet high and 9 feet wide at the opening. With a maximum allowable head of 50 feet over a horn, flow into the horn is 350 cfs. Reservoir level determines head and therefore which horn is operated at any one time.

appears low compared to that seen in other hatchery outplanting programs in the Willamette Basin (Beidler and Knapp 2005).

Year	Above Cougar Dam	Above Trail Bridge Dam
1993	55	0
1994	0	0
1995	0	0
1996	291	0
1997	1,038	63
1998	327	50
1999	549	40
2000	1,518	42
2001	2,055	61
2002	4,771	89
2003	2,981	141
2004	3,409	120
2005	868	111
2006	1,018	116

Table 4.3-3 Numbers of adult hatchery spring Chinook salmon in the McKenzie River subbasin released above Cougar Dam (USACE dam), and Trail Bridge Dam (EWEB-owned), 1993-2006. Data sources: Mamoyac and Ziller (2001), McLaughlin et al. 2008), and (Beidler and Knapp 2005)

4.3.3.1.4 Fish Passage at Blue River Dam

Blue River Dam was built without fish passage facilities and was never designed to sustain the small run of salmon that once returned to upstream areas. Before the dam was completed, 4.5 miles of Blue River were accessible to adult spring Chinook salmon, up to a 6- to 10-foot falls that was passable only under high spring flows (Willis et al. 1960). The watershed probably once supported a population of about 200 adult Chinook salmon (WNF BRRD 1996).

4.3.3.2 Water Quantity/Hydrograph

The McKenzie River drains a large subbasin along the west flank of the Cascade mountain range. The majority of runoff occurs during the winter, and flows are lowest during July, August and September. Gages in the upper basin exhibit a pronounced bimodal peak resulting from winter runoff and spring snowmelt.

In general, seasonal flow variations in the McKenzie River are less than in other Willamette River basin tributaries because of the abundance of springs and lakes in the upper basin which tend to attenuate flow fluctuations. As noted above, flows are naturally lowest in the late summer and early fall. The average daily flow in September prior to construction of the Cougar and Blue River dams was 2,030 cfs. Since construction of the projects, the average daily flow in September has increased to 2,956 cfs (Moffatt et al. 1990). Post-project summer flows are greater than occurred historically, because storage is available at USACE facilities to redistribute flood volumes and release water later in the year for flow augmentation purposes. There are no consumptive water diversions upstream of Vida (Hubbard et al. 1996).

Water development in the McKenzie basin dates back to the beginning of the 20^{th} Century and grew with the local demand for electrical energy. The Eugene Water Board (currently Eugene Water & Electric Board – EWEB) began developing the river's hydroelectric potential in 1910 with construction of Matlock Station (currently termed the Walterville development). With expanding electrical demand came the Leaburg development, which began to produce electricity in 1930. Neither of these facilities provides substantial storage and both are currently operated as run-of-river facilities. Both diversion dams were fitted with fish passage systems.

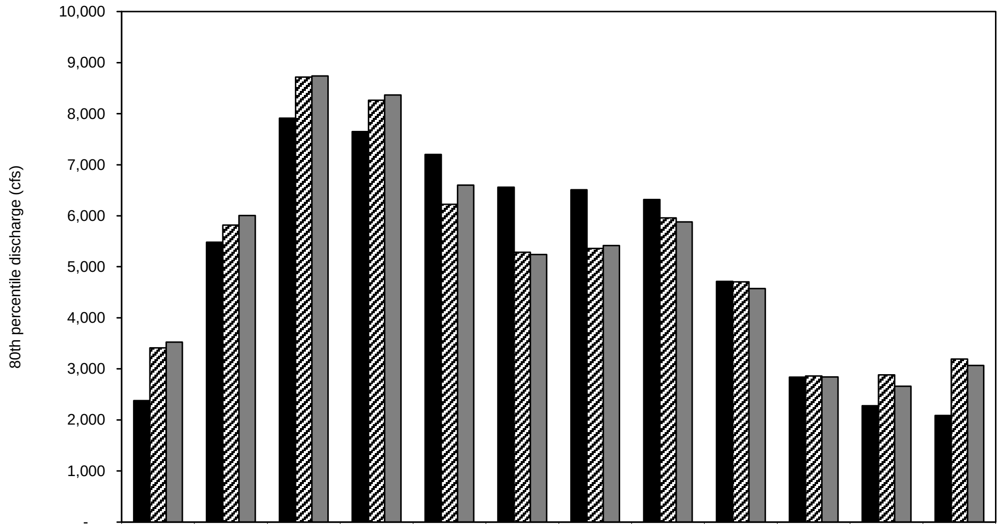
Leaburg dam and powerhouse are at RM 28 and 23, respectively with a short tailrace. Waterville dam and powerhouse are at RM 17 and 13 respectively with a 2-mile-long tailrace and terminating in a fish barrier. The Leaburg and Walterville projects directly affect 5.8 miles and 7.3 miles, respectively, with an approximately 5 mile long undeveloped reach in between. Both facilities have been recently improved to screen juvenile fish, to minimize tailrace attraction, and to maintain suitable instream flows in the diverted reaches.

EWEB also operates two dams on the upper McKenzie River (Trail Bridge and Carmen Dams), and one dam (Smith River Dam) near the headwaters. The Trail Bridge-Carmen complex was completed in 1963, the same year as Cougar Dam.

4.3.3.2.1 Seasonal Flows

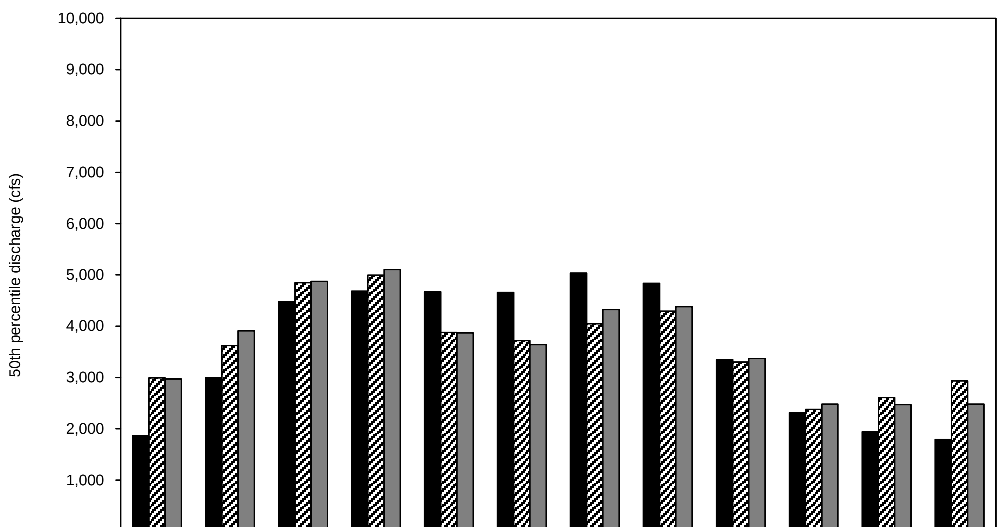
McKenzie River hydrology is strongly driven by groundwater inputs and prior to dam construction tended to display relatively constant flows (Figures 4.3-3 A, B & C). Vast areas of porous lava in the upper watershed retard surface runoff and act as a natural reservoir for large, relatively constant-flowing springs. Winter (December through February) monthly median flows were only about 2½ times as high as late summer (August and September) monthly median flows and the minimum flows recorded at Vida, Oregon. The majority of runoff occurs during winter, and flows are lowest during July, August, and September. Operation of Blue River Dam has reduced median daily April flows in the lower 1.8 miles of Blue River by 46% and has increased median daily August flows by 353% (Figures 4.3-4 A, B & C). Operation of Cougar Dam has reduced median daily April flows in the South Fork McKenzie River by 44% and has increased median daily August flows by 121% (Figures 4.3-5 A, B & C). The combined operation of Blue River and Cougar dams has reduced median daily April flows in the mainstem McKenzie River at Vida by 14% and has increased median daily August flows by 27% (Figures 4.3-3 A, B & C).

Figures 4.3-3 A, B & C Simulated discharge (cfs) of McKenzie River at Vida, Oregon under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



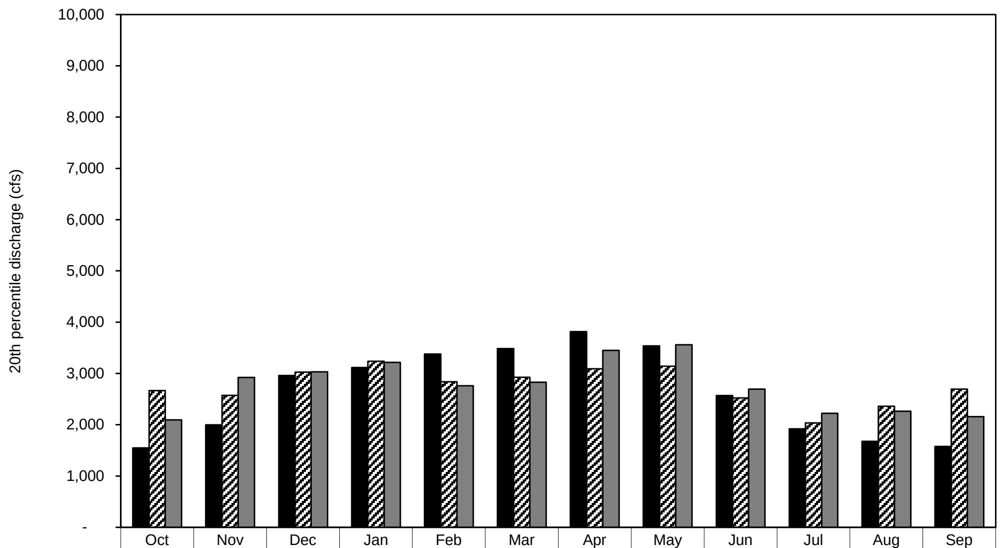
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	2,379	5,482	7,914	7,648	7,201	6,556	6,509	6,318	4,715	2,840	2,281	2,085
Pre-2000	3,415	5,816	8,717	8,260	6,223	5,286	5,360	5,958	4,703	2,863	2,882	3,193
Post-2000	3,526	6,004	8,738	8,365	6,603	5,244	5,419	5,881	4,574	2,844	2,662	3,070

Figure 4.3-3 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	1,865	2,996	4,483	4,683	4,672	4,659	5,038	4,837	3,348	2,315	1,942	1,791
Pre-2000	2,994	3,625	4,848	4,993	3,881	3,721	4,049	4,294	3,303	2,379	2,612	2,935
Post 2000	2,972	3,911	4,871	5,104	3,870	3,644	4,323	4,382	3,371	2,480	2,474	2,482

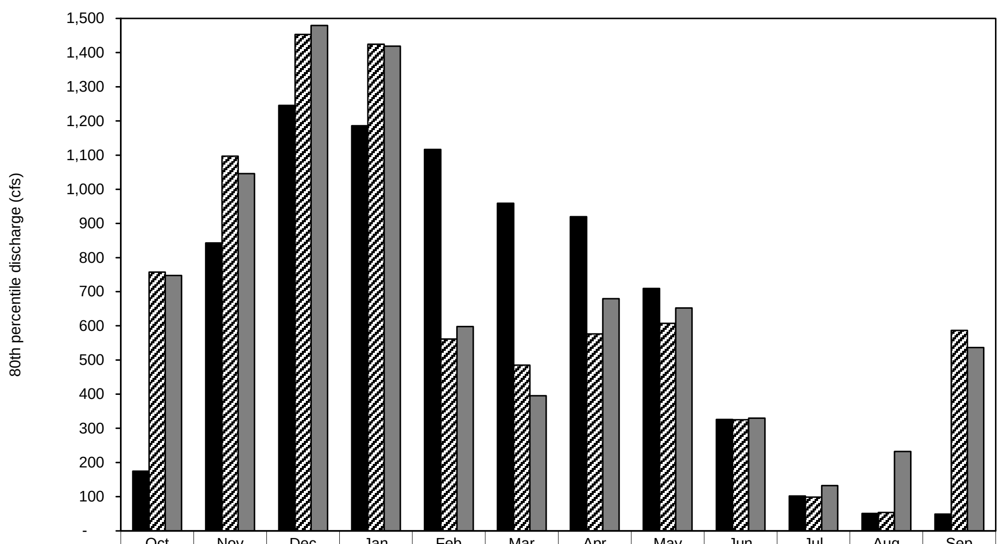
Figure 4.3-3 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	1,550	1,996	2,962	3,114	3,376	3,486	3,814	3,538	2,569	1,923	1,677	1,576
Pre-2000	2,667	2,576	3,028	3,237	2,839	2,927	3,091	3,140	2,526	2,036	2,361	2,698
Post 2000	2,094	2,922	3,033	3,218	2,760	2,831	3,449	3,561	2,695	2,224	2,263	2,160

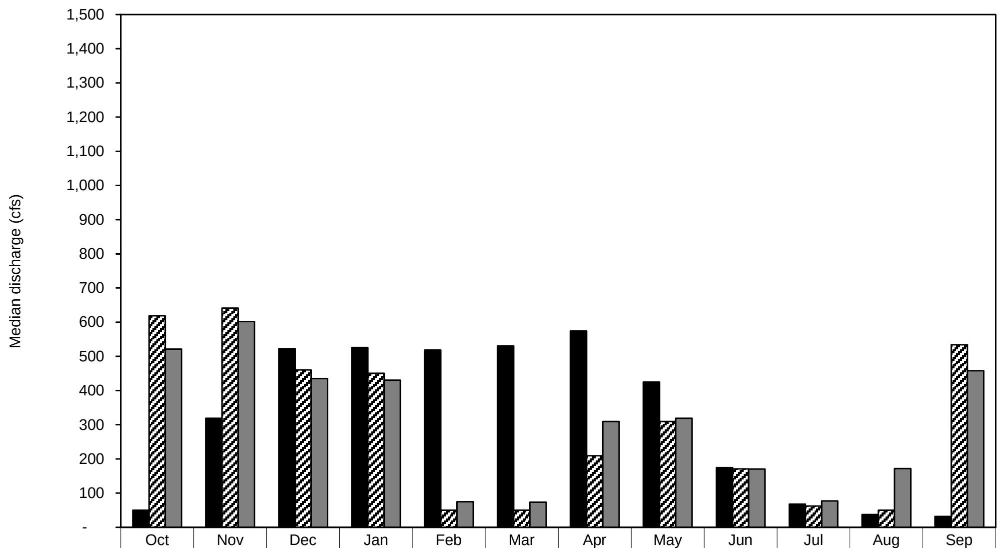
Figure 4.3-3 C

Figures 4.3-4 A, B & C Simulated discharge (cfs) of the Blue River below Blue River Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



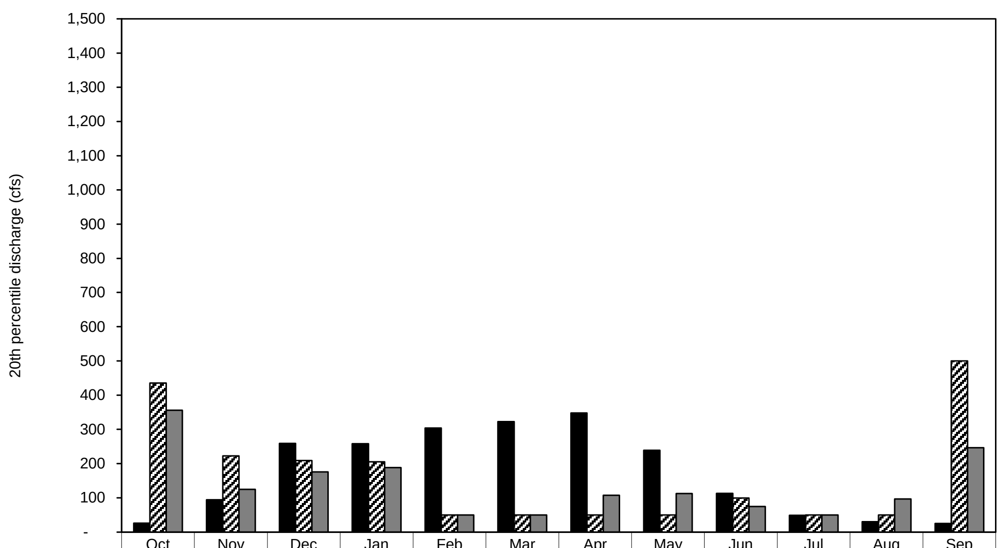
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	175	843	1,245	1,186	1,116	959	920	709	326	102	51	49
Pre-2000	757	1,097	1,453	1,425	561	485	577	607	325	99	54	587
Post 2000	748	1,046	1,480	1,419	598	395	680	653	330	132	233	537

Figure 4.3-4 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	50	319	523	526	519	531	574	425	175	68	38	32
Pre-2000	618	641	460	451	50	50	209	310	171	63	50	534
Post 2000	521	602	435	431	75	74	310	319	170	77	172	458

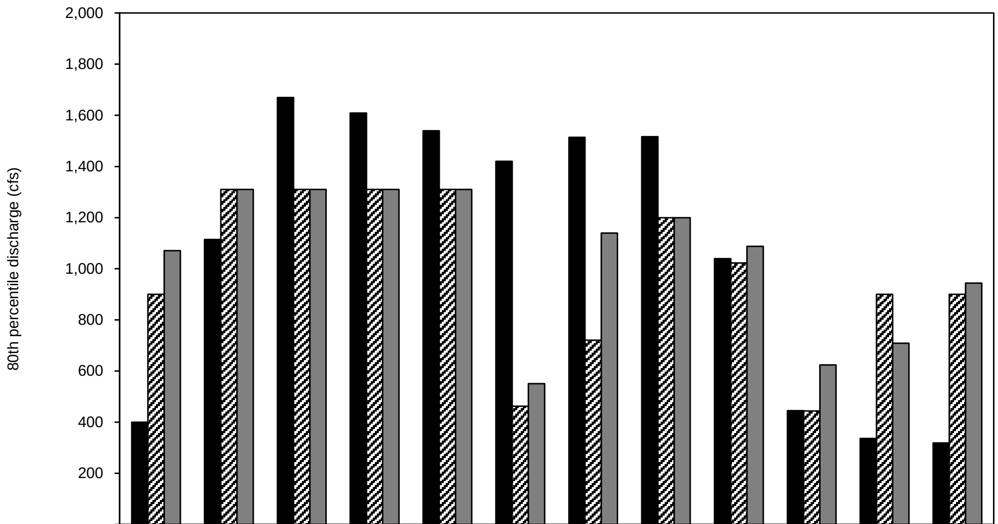
Figure 4.3-4 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	26	94	259	258	304	322	348	239	113	49	30	25
Pre-2000	435	223	209	205	50	50	50	50	99	50	50	500
Post-2000	356	125	176	188	50	50	108	113	75	50	97	246

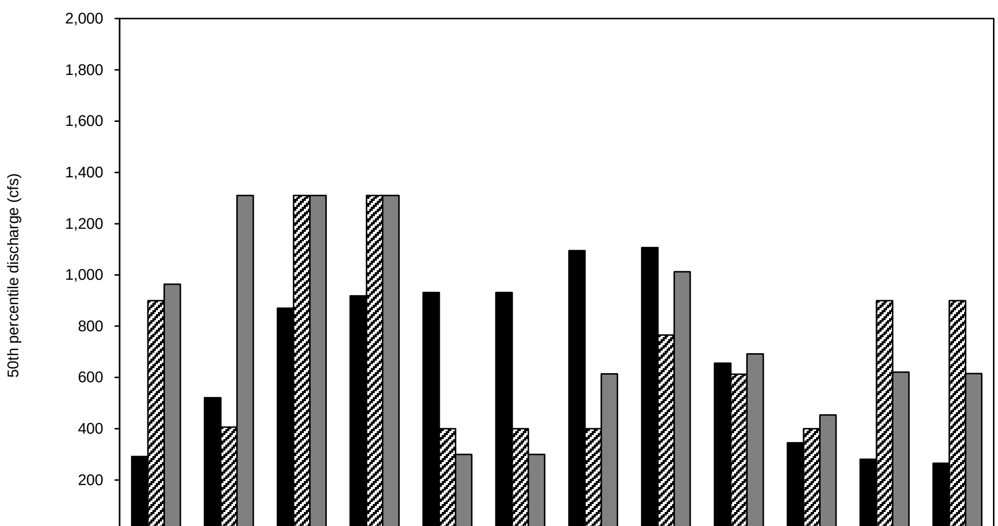
Figure 4.3-4 C

Figures 4.3-5 A, B &C Simulated discharge (cfs) of South Fork McKenzie below Cougar Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



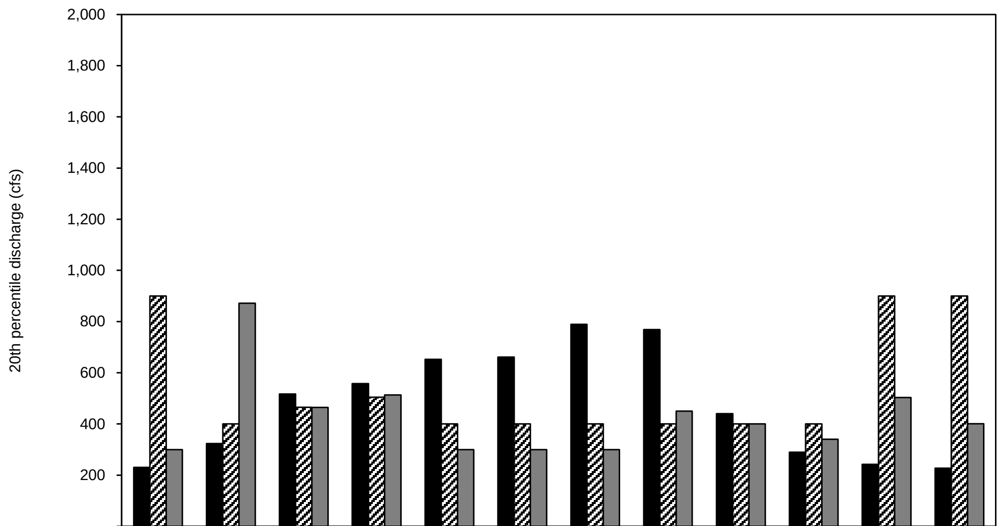
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	400	1,114	1,670	1,609	1,540	1,420	1,514	1,516	1,040	445	336	319
Pre-2000	900	1,310	1,310	1,310	1,310	462	720	1,200	1,023	444	900	900
Post-2000	1,071	1,310	1,310	1,310	1,310	551	1,139	1,200	1,088	624	709	944

Figure 4.3-5 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	292	521	871	919	931	932	1,095	1,106	656	346	281	265
Pre-2000	900	407	1,310	1,310	400	400	400	766	613	400	900	900
Post-2000	964	1,310	1,310	1,310	300	300	614	1,013	692	454	621	616

Figure 4.3-5 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	230	323	517	558	653	661	789	769	440	290	242	227
Pre-2000	900	400	465	505	400	400	400	400	400	400	900	900
Post-2000	300	872	464	514	300	300	300	450	400	341	504	401

Figure 4.3-5 C

Prior to dam construction, low flows typically occurred during August and September in the Blue and South Fork McKenzie rivers. Since dam construction, low flows typically occur during April (when the USACE refills the reservoirs before the summer recreation season), or July (before large withdrawals are need to protect water quality downstream in the mainstem Willamette), or September (due to natural precipitation and runoff conditions). Before dam construction, the lowest average daily flow observed in Blue River was 14 cfs in October 1939. After construction, the lowest flow has been 3.7 cfs, observed in October 1969. In recent years, flows in Blue River have seldom fallen below 30 cfs. In the South Fork McKenzie River, the lowest pre-dam average daily flow was 200 cfs, in October 1960. Since dam construction, the lowest average daily flow has been 85 cfs, observed during April 1977, presumably to maximize refill, probably during that year's severe drought. During winter high flow events, Cougar Dam discharge rates may decrease to about 100 cfs to reduce flooding in the McKenzie and Willamette rivers. In recent years, flows lower than 200 cfs downstream from Cougar Dam have been rare.

In recent years, USACE has attempted to meet flow targets established in cooperation with ODFW for downstream fish protection. At Cougar Dam these flows are 400 cfs year-round. At Blue River Dam these flows are 50 cfs year-round. However, the USACE has reduced flows below these target minima when necessary to reduce downstream flood risks and during other emergencies.

The McKenzie River has been extensively developed to supply water for agricultural, municipal, and industrial land uses. The OWRD has issued permits for surface water withdrawals totaling 11,994 cfs from the McKenzie River. This is a maximum allowable diversion right, and actual diversions are much lower at any particular time. Almost all of the water diverted for hydropower use and roughly half the water diverted for other uses returns to the river downstream from the point of diversion. Flows in the river reaches between the point of diversion (e.g., the Leaburg and Walterville canals) and the point of return (e.g., Leaburg and Walterville powerhouse tailraces) are at times substantially reduced.

The OWRD water availability process (OAR 690-400-011) has determined that natural flow is available for out-of-stream use in all months from the McKenzie River at the confluence with the Willamette River (OWRD 2008). However, the Willamette Basin Program Classifications (OAR 690-502-0110) require that new surface water users in the sub-basin obtain water service contracts from USBR (i.e., for use of water stored in Willamette Project reservoirs) for uses that would include the summer months (e.g., irrigation). The USBR has issued contracts for 2,373 acre-feet of water from Cougar and Blue River reservoirs (Eggers 2002).

The largest diversions from the McKenzie River are associated with hydropower developments. At River Mile (RM) 35 Leaburg Dam diverts up to 2,500 cfs into the Leaburg canal, which reduces flows in about 5.8 miles of the McKenzie River. Flows in the reach between the diversion and the powerhouse tailrace may be reduced to 1,000 cfs in accordance with the project's hydropower license (FERC 1996). At about RM 25, up to 2,577 cfs is diverted into the Walterville canal, which reduces flows in about 7.3 miles of the McKenzie River. Flows in the intervening river reach may also be reduced to 1,000 cfs. Flows approaching these minima are most likely to occur during July, August, September, and October. The river also provides domestic water supplies to the city of Eugene, Oregon, through a diversion located at Hayden Bridge (maximum withdrawal rate of 300 cfs).

To prevent substantial adverse effects on migrating adult or rearing juvenile UWR spring Chinook, the FERC license issued for the Leaburg-Walterville Project requires that EWEB maintain flows of 1,000 cfs in the 5.8-mile river reach bypassed by the Leaburg project and the 7.3-mile river reach bypassed by the Walterville project. Reducing flows to 1,000 cfs increases the river's response to summer heat. EWEB estimated that by reducing flows to 1,000 cfs in the McKenzie River's bypassed reaches, the Leaburg-Walterville project typically increased August water temperatures by about 0.7 ˚C during normal years (EA Engineering 1994). Water temperature effects, including "worst-case" temperature impacts for the Leaburg-Walterville project, are discussed in Section 4.3.3.3.

Cougar and Blue River Dams' effects of reducing late winter and spring flows on UWR spring Chinook are unknown. Of concern is the difference between flows in late summer and early fall, when spring Chinook select spawning sites and the reservoirs are being drafted for flow augmentation and flood control, and the minimum flows discharged during active flood control operations in the winter. This difference can result in redds established in the late summer and fall being dewatered during the winter, prior to emergence. Depending on the duration and rate of desiccation, dewatering salmon redds can kill incubating eggs and alevins (Reiser and White1983). It can also cause entrapment and stranding of juvenile salmonids. The potential for these project-caused effects is greatest in the South Fork McKenzie downstream from Cougar Dam, which is an important spawning and rearing area for spring Chinook.

The increase in late summer and fall flows provided by flow augmentation operations at Cougar and Blue River dams probably benefits juvenile salmonids by increasing habitat area and reducing the rate that water temperature responds to thermal loads (increased heat capacity).

Increased fall flows associated with reservoir drafting to provide flood storage may affect spawning spring Chinook that spawn downstream from Cougar Dam. Increasing flows increases the habitat area available to spawning fish. However, this increase in areal dispersion of spawning opportunity increases the risk that subsequent sudden discharge reductions would harm incubating eggs by dewatering them (see Flow fluctuations, above).

4.3.3.2.2 Peak Flow Reduction

Peak flows on the McKenzie River have been controlled by Cougar and Blue River dams since 1963. EWEB's Carmen-Trail Bridge complex also attenuates peak flows. The combined operations of these projects has substantially decreased the magnitude and frequency of extreme high flow events in the lower river, although the influence of the Carmen-Trail Bridge complex is small relative to the USACE projects because they are small and operated essentially as run-of-the-river projects. Prior to dam construction, the highest flow recorded on the McKenzie River at Vida was 64,400 cfs in December 1945 with flows greater than 40,000 cfs were not uncommon (Hubbard et al. 1996). Since construction of the projects, the two-year recurrence interval event at Vida has decreased from about 29,200 cfs to about 17,500 cfs; no flows greater than about 35,000 cfs have occurred.

Prior to 1963, when work on the Cougar and Blue River projects began, the highest flow at Vida, Oregon was 64,400 cfs, recorded in December 1945, and annual peak flows greater than 40,000 cfs were common (Hubbard et al. 1997). Since construction (1970), the magnitude of the two-year recurrence interval event has decreased from about 29,200 cfs to 17,500 cfs and no events have exceeded 35,000 cfs.

Reductions in peak flows caused by flood control operations at Blue River and Cougar dams have contributed to the loss of habitat complexity in the McKenzie River by substantially reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control tends to reduce channel complexity (e.g., reduces the frequency of side channels, and woody debris recruitment) and reduce the movement and recruitment of channel substrates. Side channels, backwaters, and instream woody debris accumulations have been shown to be important habitat features for rearing juvenile salmonids.

The operation of USACE's Blue River and Cougar dams is only partly responsible for the reduction in channel complexity noted in the McKenzie River. Bank stabilization measures and land leveling and development in the basin have directly reduced channel complexity and associated juvenile salmon rearing habitat (Section 5.2.3). Changes in channel form in response to reductions in peak flows are probably highest in the unconfined portions of the channel, which extend from near Vida to the river's confluence with the Willamette River in Springfield, Oregon.

Armoring, the process of increasing the dominant substrate particle sizes, also reduces the availability of suitable spawning substrates. EA Engineering (1991) and Minear (1994) have documented channel armoring in the lower McKenzie River.

These effects in the McKenzie River downstream from Blue River and Cougar dams persist unabated through most of the river downstream from Blue River, Oregon because of the lack of any sizable downstream tributaries that could replenish flows or sediment and woody debris loads. These effects are exacerbated by storage of sediment and woody debris in the Leaburg Dam pool.

Controlling peak flows beneficially reduces the potential for scouring UWR Chinook redds during extreme flow events.

4.3.3.2.3 Flow Fluctuations, Entrapment and Stranding

Juvenile salmonids may become entrapped and stranded in the South Fork McKenzie River when discharge is reduced precipitously at Cougar Dam during winter flood events. The South Fork McKenzie River downstream from Cougar Dam is an important spawning and rearing area for UWR Chinook salmon. Salmon fry currently emerge from January through March, the flood control/refill season, and juveniles reside in the river year-round.[3] This potential effect is somewhat reduced by channel morphometry. The South Fork McKenzie River channel is relatively well confined downstream from Cougar Dam (i.e., the valley is narrow and the total wetted area changes relatively slowly, with discharge over a wide range of flows). However, at some low flow conditions, the stream's wetted area would begin to rapidly decrease with decreases in flow, increasing the potential for entrapment and stranding. The flow at which this break-point in the wetted area v. flow relationship occurs is presently unknown.

Rapid discharge reductions at Blue River Dam may also affect juvenile salmonids, but this potential is reduced by the very low numbers of juvenile salmonids known to rear in the Blue River. The potential for rapid flow reductions during flood control operations to cause entrapment and stranding in the mainstem McKenzie River is small, as these projects control only about 36 % of the river's runoff upstream of Blue River, Oregon (Minear 1994). When flows high enough to warrant flood control operations at Cougar and Blue River dams are occurring, flows in the mainstem McKenzie River would likely be high enough to mask the diminishment caused by dam operations.

Historically, ramping rates at Cougar Dam were limited to 500 cfs per hour during high flow and 200 cfs per hour during low flow (USACE 2000). Changes in river stage corresponding to these discharge ramping rates have not been defined. Upramping limits at Blue River range from 50 cfs per hour at total project flows of 50 to 100 cfs to 600 cfs per hour at flows greater than 2000 cfs (USACE 2000). The maximum downramping rate was 30% of total project discharge per hour.

Ramping operations at Cougar and Blue River dams were modified in 2006 to reduce fishery impacts. Currently, USACE attempts to maintain ramping rates of 0.1 ft. per hour at night and 0.2 ft. per hour during daylight hours except during active flood damage reduction operations.

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[3] Recent emergence timing was earlier than would have occurred prior to project development, due to the thermal effects of Cougar reservoir. This problem has been addressed by completion and operation of the Cougar Water Temperature Control Project. The project is operated to mimic pre-dam water temperatures. Overwintering juveniles would continue to be susceptible to entrapment and stranding, but juveniles tend to hold in somewhat deeper water than emerged fry and are thus less likely to be entrapped and stranded.

4.3.3.2.4 Summary

Human-caused alterations of the hydrologic regimes of the lower McKenzie River and its principal tributaries have generally diminished flow-related habitat quantity and quality and have probably reduced the abundance, productivity, and life history diversity of UWR Chinook salmon and limited the production potential of accessible habitat in much of the basin. Recent agreements to meet minimum streamflows at the Leaburg-Walterville Project, Blue River Dam, and Cougar Dam have likely provided sufficient flow for upstream migration and juvenile rearing habitat requirements, but these flow increases do not address water temperature conditions in the South Fork McKenzie, described in section 4.3.3.3 below. Large storage dams in the subbasin have reduced the magnitude and frequency of large flow events in the mainstem McKenzie, preventing channel forming processes that maintain complex habitat for rearing Chinook salmon.

4.3.3.3 Water Quality

Owing to the dominance of spring discharges in the river's headwaters with groundwater residence times of 5 to 10 years (Grant et al. 2004), the McKenzie has excellent natural water quality with low concentrations of nutrients (nitrogen and phosphorus), very low sediment loads and turbidity, high concentrations to dissolved oxygen, and a neutral pH. Human activity has added small amounts of waste contaminants (e.g., fecal coliforms) to the river, and dam operations have altered the river's thermal regime and to a modest extent, total dissolved gas concentrations.

4.3.3.3.1 Water Temperatures

Until 2006, both the USACE's Cougar and Blue River projects substantially altered downstream water temperatures in the lower South Fork McKenzie and Blue River, respectively, and, to a lesser extent, in the mainstem McKenzie downstream to below Leaburg Dam (RM 38). Outflow temperatures were cooler than inflow in the late spring and summer and warmer than inflow in fall and early winter (USACE 2000). By the time water reached the mainstem McKenzie River, the effect of temperature shifts due to USACE operations was moderated by flows originating above the mouth of Blue River as well as equilibration between stream and ambient air temperatures over 8 miles between the mouth of Blue River and Leaburg Dam (USACE 2000). This tendency for large reservoirs to offset natural water temperature regimes by a month or more is often termed "thermal inertia" and is more severe downstream from reservoirs that thermally stratify and have fixed hypolimnetic discharge intakes. Thermal inertia has an array of implications for anadromous fish survival, particularly by disrupting natural reproduction schedules (e.g., delayed spawning, accelerated incubation)

According to ODEQ's 2002 CWA section 303(d) database, water temperatures in the South Fork McKenzie below Cougar Dam exceeded the maximum for salmonid spawning, incubation, and emergence (55°F; 12.8°C) during summer and fall 1991 through 1994. Temperatures in the lower 1.8 miles of Blue River (below the USACE dam) have exceeded the maximum for salmonid spawning, incubation, and emergence, and the maxima for core migration (61°F; 16°C) and non-core rearing and adult and juvenile migration (64°F; 17.8°C). The 2002 database also indicates that the maximum temperature for spawning, incubation, and emergence has been exceeded in the mainstem McKenzie from RM 0 to RM 54.5 (Finn Rock). Temperature maxima for core rearing and non-core rearing and adult and juvenile migration have been recorded in several streams that are not affected by Willamette Project flow management: Deer Creek, the Mohawk River, and tributaries to the Mohawk River.

Cooler water temperatures in the late spring and summer probably impeded the upstream migration of UWR Chinook salmon compared to predevelopment conditions. Warmer fall/winter temperatures accelerate egg incubation and the timing of fry emergence. These factors likely subjected Chinook fry to unfavorable conditions such as high flows and scarce food, leading to poor survival. The apparent shift to later spawn timing could be a result of environmental conditions favoring late-emerging fry (Homolka and Downey 1995).

Completed in December 2004 and fully operational in 2005, the water temperature control (WTC) structure at Cougar Dam has the ability to discharge water mimicking the water temperatures that would occur without the dam (Figure 4.3-6). Operation for temperature control requires selectively withdrawing water from different elevations in the pool to meet target outflow temperatures. Decisions on the flow distribution are based on outflow and data from temperature instrumentation on the face of the structure. This instrumentation allows for effective remote operation of the selective WTC tower. In addition to controlling the volume of flows, temperature data is required to determine thermal stratification in the reservoir and finally outflow temperatures. The capability to mix water from different levels to achieve a target temperature and volume is required. Gates can be "throttled" at different levels to control the proportion of flow from different levels. In addition, the electrical generation system was upgraded to include replacement of turbine runners with minimum gap technology intended to improve fish passage survival.

Since its initial operation in January 2005, the newly constructed WTC structure has substantially shifted Cougar Dam's discharge thermal regime toward natural conditions for the South Fork of the McKenzie River downstream from the dam. Cougar Dam is the only federal project in the Willamette Basin with temperature control capability. At the present time, biological responses to these physical changes have not been fully evaluated.

Water Temperature Control & Site-Specific TMDL Requirements

Operating projects to optimize temperature conditions downstream for fish is often inconsistent with TMDL temperature targets, even with a temperature control tower such as the one constructed at Cougar Dam. Experience in implementing water temperature control operations in the Sound Fork McKenzie River downstream of Cougar Dam to achieve more normative water temperatures suggest that special site-specific considerations may be required for such actions with respect to achieving ODEQ TMDLs. An operational requirement for successfully avoiding high temperature discharges in the fall (i.e., during spring Chinook salmon incubation) is to evacuate as much warm surface water as possible from the reservoir throughout the summer months while operating within the range of appropriate downstream temperature criteria for each month identified by ODFW. That is, it is necessary to balance the effect of warm water temperatures downstream of the dam across the spring, summer and fall periods to achieve the most appropriate overall biological effect. In the South Fork McKenzie River, the requirement resulted in summer water temperatures below Cougar Dam that were will above the draft TMDLs identified by ODEQ during April through September (Figure 4.3-6) in order to provide more favorable temperatures during the critical incubation period in the fall. A focus on achieving the cooler TMDL temperature targets during summer would have adversely affected the temperature conditions achievable during the fall spawning and incubation period for spring Chinook because more warm surface water would have been retained in the reservoir over summer.

By diverting water EWEB's Leaburg Dam and Walterville diversion affect mainstem McKenzie River water temperatures. These two projects affect flows and water temperatures in a 5.8-mile stretch between Leaburg Dam and the confluence with the tailrace of the Leaburg powerhouse (called the "Leaburg bypass reach") and a 7.3-mile section between the intake for the Walterville powerhouse and the point of confluence with the Walterville tailrace (the "Walterville bypass reach"). The water temperature model developed during the FERC relicensing process predicted that, under a worst-case (hot and dry) climatological scenario, water temperatures could become elevated by 2.7 and 3.6°F (1.5 and 2.0°C), respectively, at the lower end of each mainstem bypass reach (EA Engineering 1994) and may occasionally cause the water temperatures to exceed Oregon state standards.

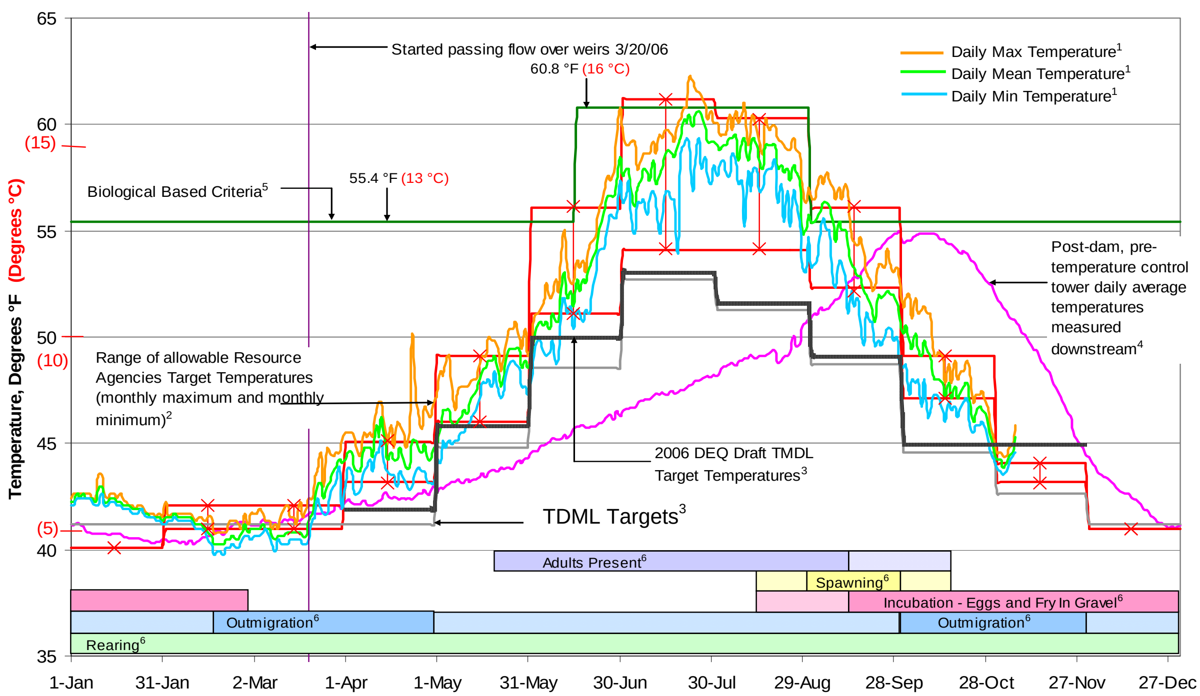

Figure 4.3-6 Cougar Dam daily discharge water temperatures for 2006, regulatory targets and pre-water temperature control discharge water temperatures in the South Fork McKenzie River downstream from Cougar Dam (USACE 2007a, Figure 3-12.)

Notes:

[1] Downstream temperatures measured at USGS gage 14159500 located 0.6 miles downstream of dam.

[2] Resource Agencies Target Temperatures from letter dated September 14, 1984, signed by representatives from NOAA, FWS, and ODFW.

[3] Willamette TMDL as approved by EPA on September 29, 2006.

[4] Daily average historical temperatures below Cougar Dam from 01OCT1963 to 30SEP2003 measured at USGS gage 14159500 located 0.6 miles downstream of dam.

[5] Biological criteria developed by DEQ as outlined in Oregon Administrative Rules (OAR), Chapter 340, Division 041, *Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon.*

[6] Life history of Spring Chinook above Willamette Falls, below Willamette Reservoir taken from Willamette Project Biological Assessment, April 2000. Dark Color represents normal peak period.

4.3.3.3.2 Dissolved Oxygen

In a USGS study (Pogue and Anderson 1995), dissolved oxygen concentrations in the lower mainstem McKenzie River (between RM 7.1 and 19.3) attained levels required for salmonid spawning and rearing during both the July and August 1994 sampling periods. The 2002 CWA 303(d) database shows that dissolved oxygen concentrations below ODEQ's numerical criterion for salmonid spawning (i.e., <11.0 mg/L or 95% saturation) were recorded at RM 1.5 in the Mohawk River, an unregulated tributary to the mainstem McKenzie, during October 1 through May 31.

4.3.3.3.3 Total Dissolved Gas

Monk et al. (1975) measured TDG levels of 97.8% to 124.1% saturation near the base of Cougar Dam; 99.5% to 115.7% at a site 3,000 feet downstream; and 103.4% to 108.6% at a site 2.7 miles downstream, during November (1970), when yolk sac fry may have been present. In April 2006, USACE tested TDG under increasing spill from the Cougar Dam regulating outlet and turbine discharge ranging from 0 to 530 cfs (Britton 2006). When regulating outlet discharge reached 2000 cfs, TDG exceeded 120% in the South Fork McKenzie just below the confluence of the regulating outlet channel and the tailrace. Because TDG is compensated at greater depths,[4] TDG was estimated at 100% at depths ranging from 0.8 to 2.2 meters. The risk of gas bubble trauma during spills at the dam would thus tend to be at the depth of redds constructed under the low flow conditions typical of the spring Chinook spawning season, but juvenile Chinook nearer the water surface might be at risk. Levels of dissolved gases measured below Blue River Dam in March (1971 and 1972) ranged from 107.9% to 120.4% saturation. Symptoms of gas bubble trauma have not been reported in juvenile or adult anadromous salmonids in the McKenzie subbasin.

4.3.3.3.4 Turbidity

Turbidity is generally very low in the South Fork and mainstem McKenzie rivers; background levels are less than 5 NTU.

2002 Turbidity event

During the spring of 2002, as the USACE drew down Cougar Reservoir to prepare for construction of the water temperature control tower, the South Fork McKenzie River incised a channel through the sediment delta at the head of the reservoir that had formed due to impoundment. Some of the sediments remobilized by this process were released in a turbid plume, detectable from April through July, 2002. The median turbidity recorded from April 1 to June 16 at USGS Station No. 14159500 (approximately ½ mile below the dam) was 98 NTU. The measurements included a maximum of 379 NTU on April 28 (USACE 2007a). Further, sampling revealed DDT and its byproducts in the reservoir sediments. DDT is highly toxic to aquatic life and the potential for mobilization caused concern. The extended period of elevated turbidity raised questions about potential effects on spawning gravels, juvenile and adult spring Chinook salmon, and macroinvertebrate communities that are integral to the Chinook salmon food web (NMFS 2002).

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[4] For example, Weitkamp, D.E., and Katz, M. A Review of Dissolved Gas Supersaturation Literature. Transaction of the American Fisheries Society 9:659-702, 1980. This paper notes that depth compensates for supersaturation at an approximate rate of 10%/meter of depth.

In response to NMFS' request to examine the effects of the sustained turbidity event, the USACE contracted with researchers from Oregon State University's Department of Geosciences and the USFS' Pacific Research Station to determine (1) to what extent and depth fine sediments associated with the reservoir drawdown intruded into gravels in the South Fork McKenzie below the dam, and (2) how much of the sediment released from the reservoir traveled in suspension through the McKenzie system and how much had settled out of suspension and was still stored in the subbasin. The first objective was addressed by Stewart et al. (2002), who concluded that there were higher proportions of fine sediments (especially clays) in the gravel bars below Cougar Dam compared to reaches above the reservoir. Clay enrichment was highest immediately below the dam and decreased rapidly downstream; there was no discernable effect of fines (silt and clay) from Cougar Reservoir below the confluence of the South Fork and the mainstem McKenzie River. Stewart et al. could not prove that the clay enrichment below the dam occurred during the 2002 reservoir release because there were no pre-drawdown samples for comparison. However, Grant et al. (2002) observed that, after the spring 2002 turbidity events, clouds of sediment were stirred up in the South Fork below Cougar Dam, and to some extent in the mainstem McKenzie, and there did not seem to be a layer of fine sediment on the gravels above the dam. The Grant et al. (2002) observation that the turbidity event was probably the source of the fine sediment on the gravels below Cougar Dam was supported by D. Cushman, a USGS technician who has operated stream gages and monitors in the area (Anderson 2003).

Following thorough investigation by the Anderson (2007), very little long-term adverse effect of this visually spectacular event was identified. The researchers concluded that sediment concentrations entering Cougar reservoir during April 2002 were unusually high but that erosion of reservoir sediments was a substantial net contributor to downstream sediment loads. Downstream movement of DDT and byproducts of DDT, a concern due to past forest practices, was low immediately following the April 2002 event and nonexistent during later storm events. Although fine sediments were found among stream substrates downstream from Cougar Dam, all other stream reaches affected by flow regulation showed similar fine sediment accumulations leading the study team to suspect that the cause was primarily peak flow reduction associated with flood control operations, not the 2002 sediment-plume episode. These investigators suggest that prior to engaging in future projects requiring reservoir drawdown, a network of turbidity monitoring monitors should be installed, coupled with collection of suspended-sediment data prior to the drawdown to facilitate post-construction evaluation of the role of the construction on sediment transport and areas of likely deposition.

The USACE also collected samples of benthic invertebrates above and below Cougar Reservoir in August 2002 following the high turbidity events of spring 2002. The sampling design was intended to determine whether there had been immediate and catastrophic effects to benthic macroinvertebrate communities as a result of the recent drawdown and release of suspended materials. The analysis indicated that the "biotic integrity"[5] of the benthic macroinvertebrate community below Cougar Dam was degraded in comparison to the community located above the reservoir (USACE 2003). However, the same trend was observed in samples collected in 2000

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[5] Communities that score high have very high habitat complexity, are minimally impacted by human activities, and have a strong, perennial flow of cool/cold water (Aquatic Biology Associates 2000).

and 2001, before the drawdown. The USACE stated that this effect is not unusual for areas located below dams, citing studies in the Clackamas River system as an example.

4.3.3.3.5 Nutrients

The ODEQ's 2002 CWA section 303(d) database does not indicate that any streams in the McKenzie subbasin are water quality limited due to excess nutrients.

4.3.3.3.6 Toxics

The ODEQ's 2002 CWA section 303(d) database does not indicate that any streams in the McKenzie subbasin are water quality limited due to toxics.

4.3.3.4 Physical Habitat Characteristics

The McKenzie subbasin contains some of the better freshwater habitat still available to UWR Chinook, both within the Willamette Valley lowlands and in its forested uplands. This does not, however, mean that salmon habitat within the subbasin is of consistently good quality. Collectively, physical habitat in the mainstem McKenzie River and its tributaries has been affected to varying degrees by multiple unfavorable human influences. These include timber harvest activities, failures of forest roads, wood removal, rural and residential development near streams, conversions of lowland areas to agriculture, bank protection efforts, and altered patterns of water, sediment, and wood movement in riverine channels below dams. Unfavorable influences on salmon habitat within the subbasin have tended to be more pronounced in the valley lowlands or Cascade foothills than in higher elevation watersheds above Vida, where federal lands predominate. Streams on the federal lands in upper portions of the subbasin are being managed with a stronger focus on aquatic conservation than is generally seen in the private and mixed-ownership watersheds lower in the subbasin.

Substrate

Varied combinations of the influences noted above affect substrate conditions in salmon streams within the McKenzie subbasin. Above USACE dams on the South Fork McKenzie (Cougar Dam) and Blue River (Blue River Dam), and to perhaps a lesser degree above EWEB's Trail Bridge Dam on the upper McKenzie, timber harvest and roads have increased rates of sediment input to stream channels (WNF MRD 1995; WNF BRRD 1996; Stillwater Sciences 2006). These inputs have likely affected substrate composition in channels above the dams, but have not affected riverine habitats below the dams because the reservoirs created by the dams function as sediment traps.

All coarse sediment transported from the watersheds above Trail Bridge, Cougar, and Blue River dams is now captured by reservoirs and lost to the river system. This sediment contributed historically to the maintenance of high-quality riverine habitats downstream, including spawning sites for UWR Chinook, and its loss has not been without consequence. The losses of sediment, in combination with losses of large woody debris and diminished flooding, have led to a coarsening of riverbed substrates and reductions in fresh gravel bar surfaces in the mainstem McKenzie (Minear 1994), the lower South Fork (WNF BRRD 1994), and probably lower Blue River.

Substrate coarsening in riverine channels downstream of USACE and EWEB dams likely reduces the availability of spawning gravel for UWR Chinook, though the degree to which gravel availability limits the subbasin's population of these fish is unclear. Ligon et al. (1995) suggested that spawning gravel limitations may already be causing redd superimposition in the mainstem McKenzie above Leaburg Dam. However, the USACE (2000) reported that only 1% of the available gravel is used by Chinook salmon in the mainstem McKenzie River. More recently, results from habitat surveys conducted on the South Fork McKenzie below Cougar Dam point to the distribution of spawning gravels as being perhaps a bigger issue than the aggregate quantity of them in the system as a whole. The quantity (730m^2) of good spawning habitat that R2 Resource Consultants (2007) suggest is now available to UWR Chinook in the South Fork, once the McKenzie tributary most heavily used by spawning salmon, may barely be adequate to accommodate the diminished numbers of redds (up to 142) that Schroeder et al. (2005) have counted there in the last several years.

Streambed substrates in undammed salmon streams tributary to the McKenzie vary naturally and in response to differing patterns of human disturbance. Two of these streams that head in the Three Sisters Wilderness, Lost and Horse creeks, have watersheds almost entirely within the Willamette National Forest, remain well used as UWR Chinook spawning areas (Schroeder et al. 2005), and are presumed to provide desirable substrate conditions for the fish. Horse Creek, substantially the larger of these two tributaries, plays a vital role in recruiting sediment into the upper McKenzie River. Gate Creek near Vida, downstream of the South Fork and Blue River, drains a mixed-ownership watershed managed largely for timber production but is in good enough condition to remain a lightly used spawning area for UWR Chinook. Channels within the Mohawk River system that Parkhurst et al. (1950) indicate were once used by UWR Chinook have never recovered from historic logging practices, including log drives and splash damming[6], that scoured channels to bedrock in some areas and left bed instability problems in others (Huntington 2000).

Large Woody Debris

Large woody debris is an important component of high-quality salmonid habitat because it adds structural complexity, influences sediment storage and channel form, and provides hiding cover (see Appendix E). Under natural conditions it is frequently abundant in streams, and this remains the case in those forested watersheds within the McKenzie subbasin that have been least affected by old timber harvest practices and (misguided) stream cleaning operations. Such watersheds frequently have older-aged forests within many streamside areas and thus also have significant potential for the natural recruitment of additional wood to streams.

Within the portions of the McKenzie subbasin above Cougar, Blue River, and Trail Bridge dams, woody debris abundance in streams is variable. For example, many streams within the South Fork watershed above Cougar Dam fall below Forest Service targets for in-channel wood, but others, including streams in the Three Sisters Wilderness Area, often have abundant wood (WNF BRRD 1994). Many of the wilderness streams, including a significant section of the upper South Fork itself, have streamside conifers that provide high wood recruitment potential. Wood-deficient streams are common within the roaded drainage above Blue River Dam, but sections of

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[6]Timber harvesters created small "splash" dams to form temporary ponds for log storage. They would explode the dam, sending the mass of water and logs downstream, which often removed all existing large wood in a stream and frequently scoured streams down to bedrock.

Quentin, Quartz, North Fork Quartz, and Lookout creeks have reasonably high abundances of in-channel wood (WNF BRRD1996). The last two of these streams have high wood recruitment potential (WNF BRRD1996).

All woody debris that streams transport from the watersheds above Cougar, Blue River, and Trail Bridge dams (about half of the McKenzie's historic contributing area above Vida) is now trapped in reservoirs and fails to reach lower portions of the river system. Such wood is thought to have once contributed to the maintenance of high-quality salmonid habitats downstream by influencing how river channels interacted with their banks and floodplains and by providing hydraulic diversity and hiding cover. The wood could have created logjams, secondary channels, pools and stable gravel deposits, all habitats utilized by salmonids and the invertebrates upon which they feed.

Without large wood recruited from above-dam watersheds, the lower-most segments of the South Fork and Blue River, as well as the mainstem McKenzie below Trail Bridge Dam, are entirely dependent on wood recruited from their banks, floodplains, or below-dam tributaries. The lower South Fork below Cougar Dam exhibits a general lack of large woody debris and has low wood recruitment potential (WNF BRRD 1994). The same appears to be true for Blue River below its dam. Wood loading and recruitment potential are more variable along the mainstem McKenzie.

Dam-affected reaches of the mainstem McKenzie contain limited quantities of large wood due to the combined effects of reduced input and active wood removals for flood control, navigation, or commercial purposes (Minear 1994). However, the river corridor from Trail Bridge Dam down to Hendricks Bridge remains primarily conifer-dominated and capable in places of recruiting large wood to the river (Minear 1994). Opportunities for riparian wood recruitment along the river are relatively high near Trail Bridge and tend to decline in the downstream direction due to past timber harvest, increased residential or commercial development, roadway encroachment, and reduced flooding (Minear 1994). Reductions in recruitment potential become more pronounced along the river below the South Fork, where Minear (1994) indicates much of the riparian timber was harvested during the late-1950s. Within bottomlands that extend from Hendricks Bridge to the mouth, the McKenzie corridor is naturally hardwood dominated but now consists of a much-narrowed strip of vegetation with few old trees (Alsea Geospatial et al. 2000) and a low potential for recruiting large wood to the river.

The potential for the mainstem McKenzie to receive large wood from its un-dammed tributaries varies considerably among these streams. Those un-dammed tributaries that enter the river above the South Fork confluence (e.g., Deer, Lost, and Horse Creeks) are primarily in public ownership, typically have modest abundances of instream wood, and have frequent riparian patches of old-growth conifers that offer good recruitment potential (WNF BRRD 1994; WNF MRD 1997). Past wood removal from some of these streams had unfavorable effects upon the fish habitat within them, but the Forest Service has since begun placing wood back into stream channels (WNF MRD 1995). Un-dammed tributaries lower in the drainage network (e.g., Quartz Creek and Mohawk River) have watersheds with mixed or private ownership, low levels of large instream wood, and riparian corridors that often have relatively low wood recruitment potential (Weyerhaeuser 1994; BLME 1995I; Alsea Geospatial et al. 2000).

Channel Complexity, Off-channel Habitat & Floodplain Connectivity

Reductions in channel-forming flows, decreased inputs of sediment and large wood, alteration or removal of riparian vegetation, and bank armoring can all impair the formation and maintenance of complex riverine and floodplain habitats important to salmonids (Appendix E). Each of these disturbances has influenced channel conditions downstream of the dams in the McKenzie subbasin. Along the mainstem McKenzie River from EWEB's Trail Bridge Dam down to the South Fork confluence, pool habitat has declined (Sedell et al. 1991; Minear 1994) and multiple river segments have lost sinuosity and abandoned side channels (Minear 1994). The lower South Fork has down-cut, become less dynamic, experienced vegetative encroachment, and lost active alluvial features and secondary channels since the completion of Cougar Dam (WNF BRRD 1994). Losses of channel complexity have also been documented along the mainstem McKenzie between the South Fork confluence and the mouth.

Multiple researchers have documented losses of channel complexity and habitats important to salmonids within different and often over-lapping segments of the lower McKenzie River following USACE completion of flood-control dams on the South Fork and Blue River. EA Engineering (1991) interpreted historic air photos and concluded that the channel of the lower McKenzie was very active prior to dam construction, but that it became less dynamic and lost large proportions of its islands and associated habitats during a 40-year period (1950-1990) that bracketed construction. More than half of the islands (53%), island area (51%), and island edges (58%) from Deerhorn Park to the mouth were lost during this period (EA Engineering1991). Sedell et al. (1991) reported that the number of large pools in the McKenzie below Leaburg Dam decreased by 67% during a similar period (1938-1991). Alsea Geospatial et al. (2000) found that side channels are much less abundant than they once were along the river between Hendricks and Hayden bridges, but that alcoves have increased there, possibly because dampened peak flows have allowed vegetative encroachment and sediment to fill the upper ends of side channels.

Effects of Cougar and Blue River dams are only partially responsible for the channel simplification that has occurred along the lower McKenzie. Within the lower Cascade foothills and Willamette Valley lowlands, activities that have altered or removed streamside forests have also contributed (Minear 1994; Alsea Geospatial et al. 2000), as have bank stabilization measures. As of 1989 the USACE had constructed more than 10.7 miles of revetments along the river (USACE 2000), and additional riverbanks have been armored with rock rip-rap to protect private residences built after floods were controlled (Alsea Geospatial et al. 2000). The combination of artificially erosion-resistant banks and flood-control now limit channel migration and impair the ability of many sections of the lower river to create or maintain complex habitats by interacting with its floodplain. For example, side channels and alcoves have become scarce along the river downstream of the I-5 Bridge, due to extensive bank armoring installed to aid gravel extraction activities and to protect property within the City of Springfield (Alsea Geospatial et al. 2000).

Project operations that have reduced flooding of the mainstem McKenzie decrease floodplain inundation, reduce inputs of sediment, nutrients, and organic material to the river, and prevent juvenile salmon access to potential floodplain refugia during high-water events.

Riparian Reserves & Disturbance History

Riparian vegetation along streams in the McKenzie subbasin varies in response to natural differences in geology, precipitation, elevation, and disturbance regimes, and to man-caused factors including: timber harvest, road building, and other land uses. At present, near-stream vegetation is generally least disturbed in federally managed portions of the subbasin, particularly on the Willamette National Forest, and most disturbed along lowland channels passing through areas affected by agricultural or rural-residential development.

Patches of mature or old-growth forest remain within the Three Sisters Wilderness Area and along segments of multiple streams in significant federally-managed portions of the subbasin, including parts of the South Fork, Blue River, Horse Creek, and Upper McKenzie watersheds (WNF BRRD 1994, 1996; WNF MRD 1997). However, timber harvest and road networks elsewhere within the identified watersheds and on other federal forestlands in the subbasin have left many riparian areas dominated by early- to mid-successional vegetation. Streams within the private forestlands that predominate in tributary watersheds downriver from Vida, including the Mohawk River watershed, generally have recently disturbed riparian areas that are dominated by alder or young conifers and that provide reduced wood recruitment potential and potentially less shade than is found within mature riparian forests (Huntington 2000; BLME 1995a).

Riparian vegetation along the upper McKenzie River has been influenced by a variety of disturbances including timber harvest, road construction, and rural-residential development. Mature conifers now account for 17 to 39% of the riparian corridor between Trail Bridge Dam and the South Fork confluence, with the highest percentages found at the upper end of this section of river (Minear 1994). Mature conifers become sparse within the river corridor downstream of the South Fork (Minear 1994), where first younger conifers and then hardwoods are dominant.

Within its lowlands, which were once covered with a broad hardwood forest, the mainstem McKenzie is bordered by a narrow band of hardwoods and shrubs, with few trees greater than 40 years old and frequent intrusions from riverfront homes (Alsea Geospatial et al. 2000). Peak flows and woody debris necessary to maintain a dynamic channel with fresh alluvial surfaces and diverse riparian vegetation have been diminished. Riparian intrusions by agriculture, residential development, roads, USACE revetments, and private bank armoring are prevalent (Alsea Geospatial et al. 2000) and inhibit riparian recovery.

4.3.4 Hatchery Programs

McKenzie River Hatchery Chinook salmon are now listed under the ESA as a component of the UWR Chinook salmon ESU. These fish are produced at McKenzie Hatchery, released into the lower McKenzie River as smolts, harvested in fisheries, and return to the hatchery to complete the cycle. Some hatchery returns in excess of broodstock needs are typically out-planted into the South Fork McKenzie above Cougar Reservoir, the mainstem McKenzie River above Trail Bridge Dam, and the Mohawk River, all areas where they are not expected to interact with wild adult Chinook. However, many adult hatchery-origin Chinook fail to return to the hatchery and stray into the natural spawning areas of wild Chinook along the McKenzie River above and below Leaburg Dam (see Section 4.3.2.1), the South Fork McKenzie, Horse Creek, and Lost Creek.

Hatchery programs for McKenzie spring Chinook salmon, as well as other hatchery programs in the McKenzie subbasin, pose risks that ODFW, the USACE, and others are working to better define and resolve. These include:

- Adult hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- Competition with naturally produced progeny of hatchery spring Chinook.
- Predation upon wild juvenile Chinook salmon by hatchery summer steelhead smolts released into waters occupied by these fish.
- Predation upon wild juvenile Chinook salmon by hatchery rainbow trout released into waters occupied by these fish.

4.3.5 Fisheries

Until recently, wild spring Chinook salmon were subjected to relatively intense commercial and recreation fisheries in the lower Columbia and Willamette rivers that were directed primarily at the abundant hatchery-origin fish. Freshwater harvest rates for McKenzie River fish were on the order of 35-40% prior to ESA listing of UWR Chinook, but have since been reduced (Figure 4.3-7). Fishery objectives in the Willamette River have been changed to emphasize the protection of natural-origin fish.

The State of Oregon developed a Fisheries Management and Evaluation Plan under NMFS' 4(d) Rule for the management of spring Chinook salmon fisheries in the Willamette River. This management plan specifies the harvest regime for spring Chinook salmon and has been approved by NMFS under the ESA. Total mortality in commercial and sport fisheries occurring in freshwater are capped at 15%. However, annual mortality rates since implementation of selective, catch-and-release fisheries for wild spring Chinook have more typically been in the range of 8-12% (ODFW 2008c). Impacts on natural-origin spring Chinook have been significantly reduced while maintaining a relatively high harvest of hatchery-origin adults.

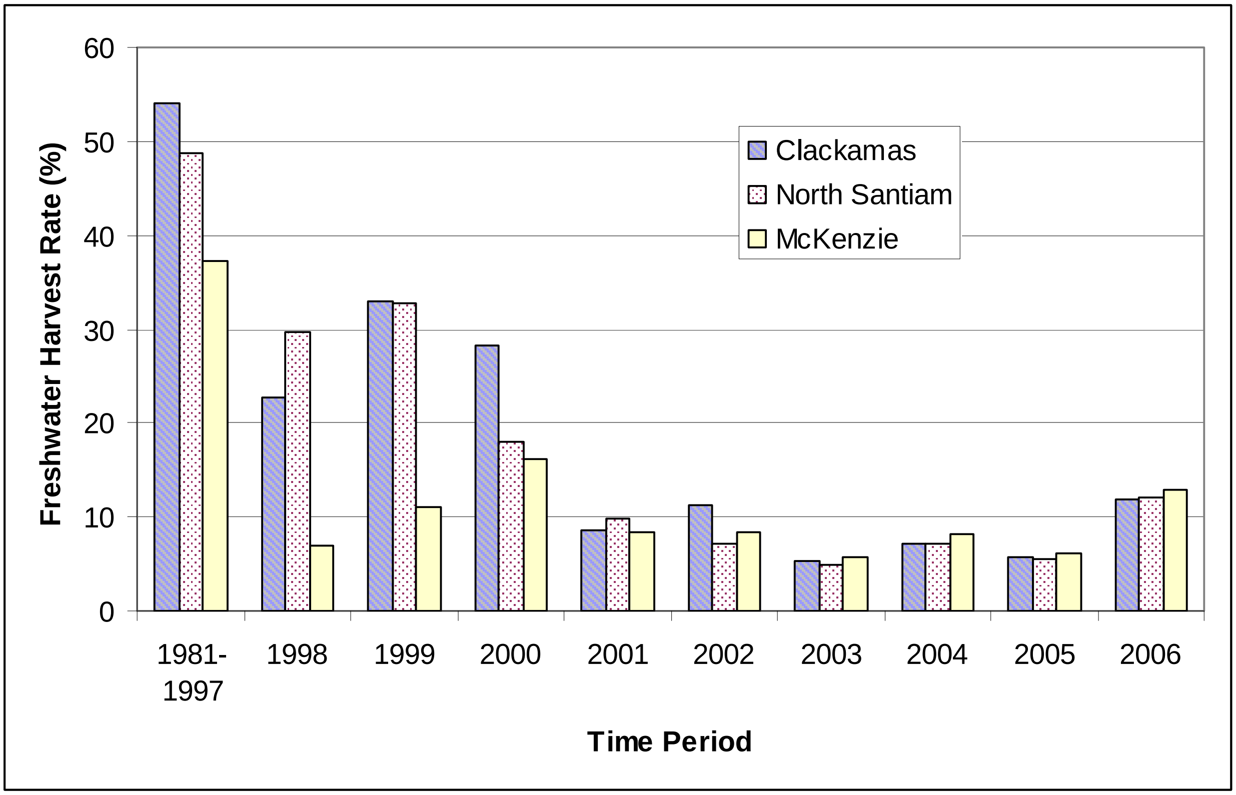

Figure 4.3-7 Exploitation rates of Willamette spring Chinook in freshwater commercial and sport fisheries. Data from ODFW (2008c).

4.3.6 Status of PCEs of Designated Critical Habitat in the McKenzie Subbasin

NMFS has determined that the following occupied or potentially occupied areas of the McKenzie subbasin either contain or do not contain Critical Habitat for UWR Chinook, as indicated (NMFS 2005d; maps are included in section 3.3 of this Opinion):

- Habitat of high conservation value for these fish, and thus important to their recovery, is present in five of the seven watersheds within the McKenzie subbasin (NMFS 2005g). The five watersheds include Upper McKenzie River, Horse Creek, South Fork McKenzie River, McKenzie River/Quartz Creek, and Lower McKenzie River. These watersheds were designated as Critical Habitat by NMFS (2005d) and contain 138.9 miles of PCEs for spawning rearing, 68.3 miles of PCEs for rearing/migration, and 1.8 miles of migration/presence habitat (NMFS 2005g).
- The South Fork McKenzie River watershed, where the Corps owns and operates Cougar Dam, contains 22.5 miles of spawning/rearing habitat, 18.8 miles of rearing/migration habitat, and 0.8 miles of migration/presence habitat, most of it above Cougar Dam (NMFS 2005g).
- The Lower McKenzie River watershed, which has been significantly affected by the operation of the Blue River and Cougar dams, includes 58.9 miles of spawning/rearing

habitat, 33.5 miles of rearing/migration habitat, and 2 miles of migration/presence habitat (NMFS 2005g).

- The Blue River and Mohawk River watersheds were rated by NMFS (2005g) as having lower conservation value for UWR Chinook, and were excluded from the final designation of critical habitat as described in section 3.3. Combined, these areas contain 8.5 miles of PCEs for spawning/rearing, 45.4 miles for rearing/migration, and 4.4 miles for migration/presence (NMFS 2005g). The Blue River watershed, where the Corps owns and operates Blue River Dam, provides 1.4 miles of spawning/rearing habitat, 0.1 miles of rearing/migration habitat, and 0 miles of migration/presence habitat below the dam (NMFS 2005g).

Bank protection measures, such as revetments, associated with USACE activities total 56,324 linear feet (10.7 miles) between RM 0.8 and Leaburg Dam (RM 38.8), with 18,103 feet (3.4 miles) on the right bank, and 38,221 (7.3 miles) on the left bank (USACE 2000). These measures affect spawning/rearing habitat that NMFS (2005d), designated as critical habitat, in lower McKenzie River. (NMFS 2005g).

NMFS (2005g) identified the key management activities that affect these PCEs. Key activities affecting the upper watersheds include dams, forestry, and agriculture. Key activities affecting the mid and lower watershed include road building and maintenance, channel modifications and urbanization, in addition to dams, forestry, and agriculture.

As discussed in Section 4.3.3.1, Cougar and Blue River Dams block access to upstream spawning and rearing habitats, reduce downstream migrant survival, alter flows downstream, reduce or eliminate marine-derived nutrients from these upper watersheds, and limit the downstream transport of habitat building blocks. Cougar Dam also alters the habitat above the dam by creating a 6.5 mile-long reservoir from about RM 4 to RM 10, which inundates historical spawning habitats (Myers et al. 2006). Until the WTC was completed in 2002, Cougar Dam also negatively altered downstream water temperatures. Blue River Dam also alters the habitat above the dam, with the reservoir inundating 2.7 miles of historical anadromous habitat. Blue River continues to negatively alter downstream water temperatures in Blue River and the mainstem McKenzie River below the Blue River confluence.

Table 4.3-4 summarizes the condition of PCEs within the McKenzie River subbasin. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most cases, this is the result of the past operation and the continuing effects of the existence of the Projects or the effects of other human activities (e.g., development, agriculture, and logging). However, to the extent these conditions would be perpetuated by future operations or existence of the project, only the past impacts and project existence are included in the baseline.

Table 4.3-4 Matrix of Pathways and Indicators for the condition of primary constituent elements of critical habitat in the McKenzie River Subbasin under the environmental baseline.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	Adult passage and delay, up to 14.5% mortality of outmigrating smolts, and low flows in the Leaburg and Walterville bypass reaches of the lower mainstem; corrected during 2002-2004 under terms of the new FERC license Trail Bridge and Smith dams exclude spring Chinook salmon (~8 miles) from a portion of their historical range	EWEB's Leaburg and Walterville hydro projects EWEB's and Carmen-Smith-Trail Bridge hydro projects
Freshwater migration corridors	Habitat Access	Physical Barriers	*Cougar Dam as a barrier to upstream migrants*- currently there is no upstream passage at Cougar Dam, which blocks over 37 miles of upstream historical habitat. The USACE has proposed to construct a permanent trap and haul facility to provide upstream passage. *Cougar Dam and Reservoir as a barrier to downstream migrants* -- Cougar Dam was built with juvenile fish passage facilities; juveniles entered through one of five fish horns on the upstream face of the intake tower. Fish horns collected only a low percent of the juvenile Chinook in the reservoir; many of those were injured or killed. For hatchery-reared fingerling Chinook released into Cougar Reservoir in 1963-2002, survival was 67.4% through the regulating outlet and 93% through the turbines; survival decreased with increasing fish size.	Cougar Dam is currently an upstream migration barrier, but USACE intends to construct upstream fish passage facilities by April 2009. Cougar Dam is a downstream migration barrier and currently does not provide safe downstream fish passage conditions.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Blue River Dam as a barrier to migration* --Blue River Dam blocks access to 2.7 miles of historical habitat below a falls that was probably a natural historical barrier at low flows.	Blue River Dam is a migration barrier, and does not have up or downstream fish passage facilities.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Frequency of flows in the South Fork McKenzie, Blue River, and lower McKenzie River not of sufficient magnitude to create and maintain channel complexity and provide nutrient, organic matter, and sediment inputs from floodplain areas Flow fluctuations now occur at rates rapid enough to entrap and strand juvenile anadromous fish Increased fall flows may allow spring Chinook to spawn in areas that will be dewatered during active flood control operations Winter and spring flow reductions may reduce rearing area and the survival of steelhead fry Increased summer flows may increase rearing area and the heat capacity of the stream Low summer flows in specific reaches (due to diversions) may reduce the juvenile rearing habitat area, block adult passage to upstream spawning areas, and decrease the heat capacity of the stream.	Flood control operations at USACE's Cougar and Blue River dams reduce the magnitude and frequency of peak flows Flood control operations at USACE's Cougar Dam cause rapid flow reductions Fall releases from Cougar and Blue River reservoirs Winter flood control and late winter and spring refill operations at Cougar and Blue River dams Flow augmentation from Cougar and Blue River dams to meet mainstem flow targets Summer diversions at EWEB's Leaburg and Walterville Project

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Cooler water temperatures in the late spring and summer have impeded upstream migration of spring Chinook salmon; warmer fall/winter temperatures accelerated egg incubation and fry emergence. EWEB's Leaburg-Walterville project diverts flow into two power canals downstream of RM 38; water at lower ends of the two mainstem bypass reaches could increase by 2.7 and 3.6°F, respectively, due to diversions. The ODEQ 2004/2006 Integrated Report database indicates that temperatures in the South Fork McKenzie below Cougar Dam have exceeded the maximum for salmonid spawning and rearing (55°F; 12.8°C) during summer and fall. The ODEQ 2004/2006 Integrated Report database indicates that temperatures in the lower 1.8 miles of Blue River have exceeded the maximum for core cold-water habitat (61°F; 16°C). The ODEQ 2004/2006 Integrated Report database also indicates that the maximum for salmon and steelhead spawning has been exceeded in the mainstem McKenzie from RM 0 to RM 54.5 (Finn Rock). The ODEQ 2004/2006 Integrated Report database indicates that temperature maxima for core rearing and non-core rearing and adult and juvenile migration have been recorded in several streams that are not affected by Willamette Project flow management: Deer Creek, Horse Creek, the Mohawk River, and tributaries to the Mohawk River.	USACE operations (Cougar Dam until 2005; Blue River Dam) EWEB's Leaburg and Waterville Projects USACE operations (Cougar) USACE operations (Blue River) USACE operations (Cougar and Blue River), EWEB's Leaburg and Walterville diversions Degraded riparian areas due to clearing for floodplain development, and timber harvest.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	Generally, turbidity levels in the McKenzie subbasin are low (<5 NTUs). Release of turbid water during the spring 2002 drawdown of Cougar Reservoir for construction of the water temperature control tower resulted in elevated turbidity levels, including a maximum of 379 NTU (compared to background of 5 NTU) After the turbidity event, higher proportions of fine sediments in gravel bars below Cougar Dam compared to reaches above the reservoir; clay enrichment decreased rapidly downstream; clouds of sediment stirred up while wading in the South Fork below Cougar Dam, and to some extent in the mainstem McKenzie.	N/A USACE construction of the Cougar WTC tower
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/Nutrients	The ODEQ 2004/2006 Integrated Report database indicates that elevated concentrations of iron and manganese are present in some river reaches of the McKenzie subbasin. The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the McKenzie subbasin are water quality limited due to excess nutrients	Unknown N/A

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database indicated a low percentage of samples (6%) taken in the McKenzie River (RM 0 to 34.1) did not meet the criterion for dissolved oxygen (>11 mg/l and applicable % saturation). Insufficient data exists to determine whether ODEQ standards are met.	Unknown
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	TDG levels of 97.8 to 124.1% saturation near the base of Cougar Dam; 99.5 to 115.7% approximately 3,000 feet downstream; and 103.4 to 108.6% at a site 2.7 miles downstream during November (1970). 2006 monitoring below Cougar dam indicated that TDG levels in the RO channel ranged from about 107 percent to 118 percent for flows. Corresponding depth-compensated TDG levels ranged from below 100 percent to about 106 percent, respectively. TDG levels of 107.9 to 120.4% saturation in March (1971 and 1972) below Blue River Dam	USACE operations (Cougar Dam) USACE operations (Cougar Dam) USACE operations (Blue River Dam)

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites	Habitat Elements	Substrate	Substrate has coarsened in the mainstem McKenzie downstream of Cougar and Blue River Dams. South Fork McKenzie River downstream of Cougar reservoir has stabilized Channel downstream of USACE dams lack spawning gravel Current sediment budget not creating and maintaining habitat needed by anadromous salmonid	USACE and EWEB reservoirs trap sediment and large wood from headwaters USACE operates Cougar and Blue River Dams to reduce the magnitude and frequency of peak flows USACE and private revetments Gravel mining
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	*In Headwater Tributaries* Large wood does not meet USFS targets in some tributaries (Lower Deer Creek, Quartz Creek, Mohawk River, the South Fork and some of its tributaries) Large wood meets USFS targets in some tributaries (North Fork Quartz Creek, Lookout Creek, some South Fork tributaries) Some tributaries, such as Horse Creek, have high recruitment potential Some restoration efforts are underway in the McKenzie subbasin	Timber harvesting Stream clean-out Fire suppression

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	*In the mainstem McKenzie River--* The upper McKenzie River below EWEB's Trail Bridge Dam is deprived of large wood, although some restoration efforts have begun The South Fork McKenzie below Cougar Dam, and Blue River below Blue River Dam are deprived of large wood from the headwaters The McKenzie River below Cougar and Blue River dams is deprived of large wood from the South Fork and Blue River. Inadequate recruitment of large wood from riparian areas along mainstem McKenzie and tributaries downstream from Cougar and Blue River dams Lack of large wood-associated habitat for anadromous salmonids and invertebrates upon which they feed	USACE and EWEB remove large wood from reservoirs USACE removed snags in lower river for navigation Inadequate recruitment from riparian forests Removal of large wood by landowners and boaters for navigation and/or firewood
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Pool frequency and quality in the lower mainstem McKenzie has been reduced due to absence of pool forming elements such as LWD, reduction of channel forming flows, and bank protection measures have reduced channel migration and resulted in simplification of habitats.	Downstream LWD transport blocked by project dams; land uses such as timber harvest. Urbanization, development, and diking in the lower river.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-Channel Habitat	The South Fork McKenzie below Cougar Dam has stabilized and lost side channels The mainstem McKenzie below the Deerhorn Park lost 53% of its islands, and many side channels have filled in and become alcoves The McKenzie prior to dam construction migrated frequently, and has since stabilized The lower McKenzie is simplified and channelized, resulting in poor connectivity to off-channel habitat in lower river.	USACE operates Cougar and Blue River Dams to reduce the magnitude and frequency of peak flows, important to creating and maintaining salmonid habitats USACE and private revetments USACE and EWEB remove large wood from reservoirs Gravel mining in lower river
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Streambanks do not support natural floodplain function in the lower mainstem river, or in the South Fork reach below Cougar Dam.	Diking; residential and agricultural land uses; development; timber harvest; reservoir operations.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain connectivity	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests The lower river is disconnected from its historical floodplain by dikes and flood control operations that have reduced peak flows.	USACE operates Cougar and Blue River Dams to reduce the magnitude and frequency of peak flows USACE and private revetments Residential development Dikes; Project operations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Road density and location	High road densities exist in the lower McKenzie River Basin, including Highway 126 which runs adjacent to the McKenzie River for many miles. Road networks, including those for timber harvest, exist in the upper watershed. USACE (2007a) characterized the South Fork and Blue River watersheds as having moderate to low road densities.	Urban, agricultural, and industrial development. Timber harvest.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	*Headwater forests riparian conditions* Riparian areas in some tributaries contain mature riparian vegetation (e.g., Horse Creek and the South Fork McKenzie) but others (e.g., Quartz Creek, Mohawk River) are dominated by young alder or conifers Many tributaries do not provide adequate shading or large wood recruitment Riparian vegetation along confined reaches of the upper McKenzie River contains only 39% mature conifers *Floodplain forest riparian conditions* Many remaining patches of floodplain forest are interspersed with pastureland, highways, and residential development Extent of floodplain vegetation restricted to a narrow band along river Low large wood recruitment potential	Timber harvesting Stream clean-out practices Clearing for agriculture or development USACE and private revetments USACE operation of Cougar and Blue River Dams alters the hydrologic regime Timber harvest
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Disturbance History	Disturbance regime is dominated by timber harvesting Forests are dominated by early- to mid-successional stages, with some late-successional forests in wilderness areas in the Horse Creek and South Fork drainages Timber harvesting has increased sediment delivery to streams, but decreased large wood input, resulting in degraded aquatic habitat Upper watershed is forested, but some is managed for timber production rather than ecosystem health Lower watershed contains extensive agricultural, urban, and residential development	Fire suppression Timber harvesting Conversion to agricultural, urban, residential, and rural uses

Section 4.4
Calapooia Baseline

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4.4 CALAPOOIA SUB-BASIN

The Calapooia River subbasin is the smallest of the six east-side and upper Willamette River subbasins (Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and Middle Fork Willamette) located above Willamette Falls in the Willamette River basin. These six are the primary salmon and steelhead-bearing subbasins.

The Calapooia River flows out of the western Cascade Mountains to join the Willamette River at the City of Albany. The subbasin encompasses about 970 km^2 (240,000 acres) of land and supports a variety of land uses and fish and wildlife habitats. The subbasin's headwaters drain the south side of the Green Mountain Ridge.

Elevations within the subbasin range from 5,185 feet at the summit of Tidbits Mountain to less than 200 feet where the Calapooia River joins the Willamette River in Albany, OR. Cool rainy winters, and hot, dry summers characterize the climate of the subbasin. Only 5% of the annual precipitation falls from July through September (Hulse et al. 2002). Winter precipitation usually falls as rain in the lower elevations of the subbasin and snow in the mountainous areas above 3,500 feet.

The subbasin is fairly evenly divided between agricultural use (approximately 483 km^2 or 50% of the land use area) in the lower subbasin and forest or shrub area (approximately 429 km^2 or 44% of the land use area) in the upper subbasin, as depicted in Figures 4.4-1. Four percent (approximately 38 km^2) of the land use is in grasslands, and only about one percent (approximately 13 km^2) is currently developed.

While only a small portion of the land has been developed, the human population density in the Calapooia subbasin is second only to the Molalla subbasin among the Willamette's east-side tributaries. Major population centers within the subbasin include the southern portions of the cities of Albany, Lebanon, and Sweet Home. Ninety-four percent of the subbasin is in private ownership (Figures 4.4-1).

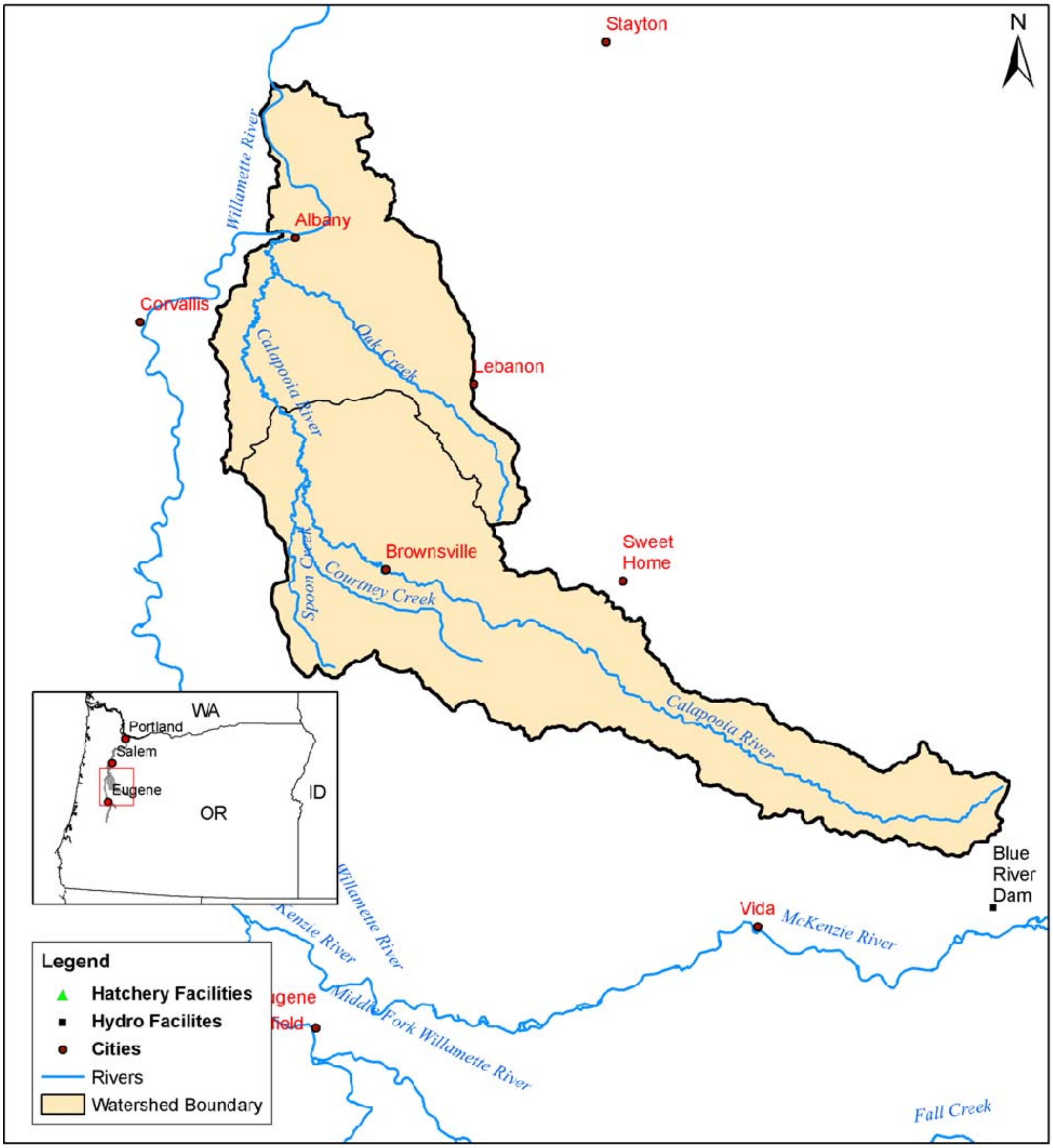
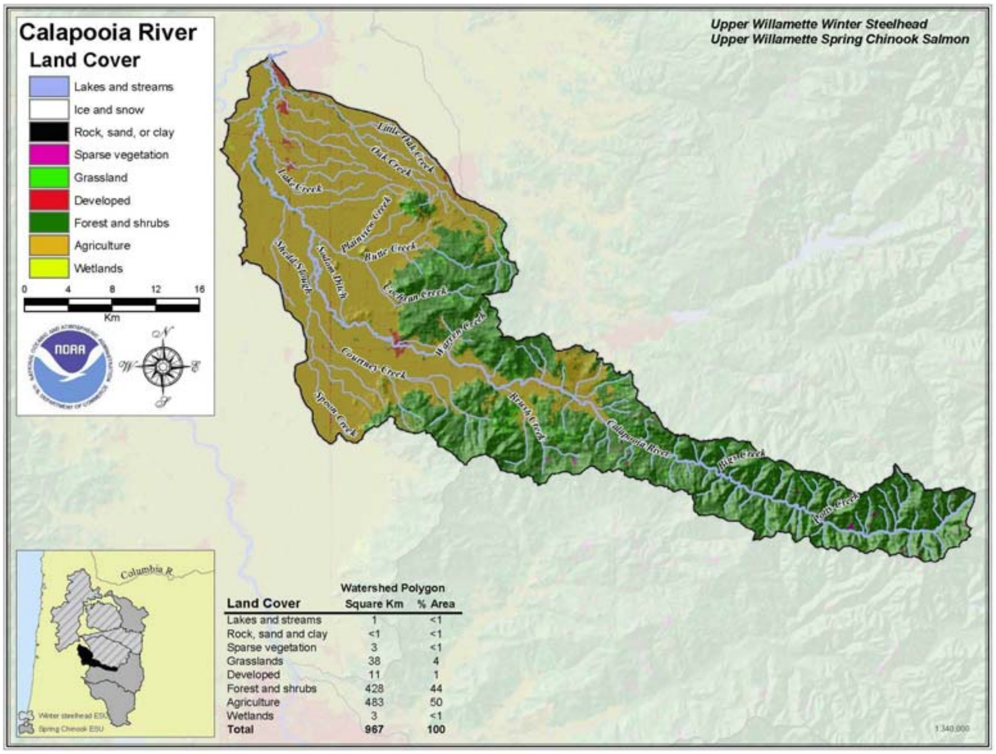
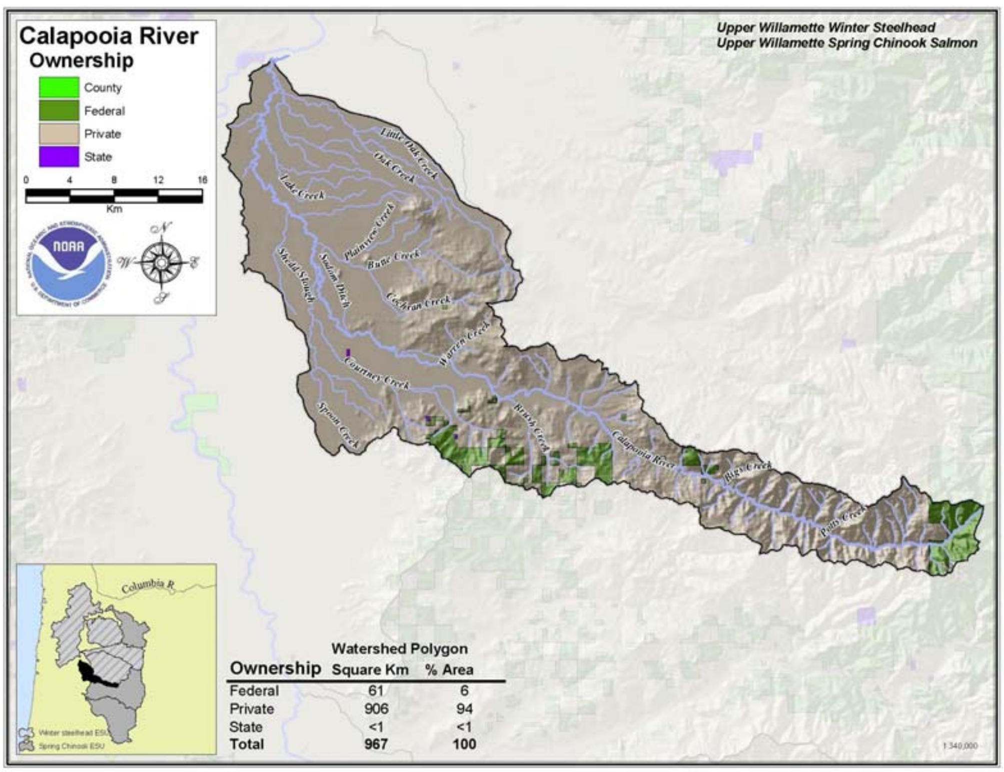


Figure 4.4 Calapooia Sub Basin





Figures 4.4-1 Location, land cover (top) and ownership patterns (bottom) of the Calapooia subbasin (source: WLCTRT 2004).

4.4.1 Historical Populations of Anadromous Salmonids in the Calapooia Subbasin Context

Both UWR Chinook salmon and UWR steelhead occur in the Calapooia River subbasin. Historically, the spring Chinook salmon run in the Calapooia River may have been in the hundreds and the winter steelhead run size may have been in excess of 1,000 adults. Mattson (1948) estimated the adult run of spring Chinook to the Calapooia River in 1947 was about 30 fish.

Most of the spring Chinook salmon and winter steelhead in the Willamette Basin spawn above Willamette Falls at Oregon City. Upper Willamette River spring Chinook are one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin. Before the construction of fish ladders at Willamette Falls, passage by returning adults was only possible during the winter and spring high flow periods. The early run timing of the Willamette River spring Chinook relative to other lower Columbia spring-run populations is an adaptation to flow conditions at the Willamette Falls. High river flows in the late winter and early spring provide the best conditions for passage over the falls. Spring Chinook enter the Willamette as 3, 4, or 5-year old fish with the presence of some jacks (young 2-year-old male fish). The run begins to enter the Willamette River in February, with the majority of the run ascending Willamette Falls in April and May.

Once above Willamette Falls, adult spring Chinook migrate upstream at an average rate of 10 to 20 miles per day (Snelling et al. 1993). Chinook enter the Calapooia River beginning in late April to May with the migration continuing into July. In observations of adult spring Chinook at Sodom Dam over several seasons, peak counts occurred in early June and fish continued to be observed at the dam until early July (ODFW 2004b). (See section 4.4.3 for a detailed discussion of passage issues on the Calapooia)

Historically, spring Chinook salmon used the Calapooia mainstem between Holley (RM 45) and just upstream from the confluence with United States Creek (RM 80) for spawning and rearing. Spawning activity began in August and could extend into November (Wevers et al. 1992).

Adult winter steelhead are present in the Calapooia River during February through May, with peak spawning in April and May (Wevers et al. 1992). Most of the winter steelhead spawning takes place in the river channel and tributary streams above Holley. Winter steelhead cannot access the upper 2 miles of the Calapooia River due to a natural waterfall on Forest Service Land above United States Creek. The North Fork Calapooia River, and Biggs, McKinley, Potts, and King creeks are important tributary streams for spawning.

The subbasin can be subdivided into three parts based upon stream gradient and other key habitat characteristics (CWC 2004). The lower subbasin extends from the confluence of the Calapooia River with the Willamette River in Albany to the upstream end of the Sodom Ditch diversion, about three miles downstream of Brownsville (RM 1 to RM 28.5). Major tributary streams joining the Calapooia River along this section include Oak, Lake, Butte, and Courtney Creeks. The valley in this portion of the subbasin is broad and relatively flat. The highest proportion of low gradient stream and river channels in the Calapooia River subbasin are within this area. The

Calapooia River through this section has less than 0.1% gradient, and most of the tributary streams are very flat, with a few steep streams confined to the upper portions of Butte, Cochran, and Courtney Creeks. The lower subbasin is characterized by wide flood plain forests with numerous side channels and ponds along the river.

The middle subbasin includes the Calapooia River from the upper end of Sodom Ditch diversion, through Brownsville, and continuing to the beginning of forest land, approximately 4 miles above Holley (RM 28.5 to RM 48). Major tributary streams in this section include Warren, Brush, Johnson, and Pugh Creeks. Within this portion of the subbasin, the Calapooia River transitions from a broad valley floor into a narrower valley surrounded by forested hillsides. The Calapooia River through this section ranges from 0.15 % to 0.44 % gradient. The tributary streams begin as steep headwater channels that transition into lower gradients as they flow out of the forested hills. In this middle portion of the Calapooia River subbasin, the river meanders across the flood plain cutting new channels and depositing gravels and wood in the channel.

The upper subbasin includes the Calapooia River from the beginning of forest land above Holley to the mountainous upper subbasin on U.S. Forest Service land (RM 48 to RM 75). Major tributary streams include Biggs, McKinley, and Potts Creeks, and the North Fork of the Calapooia River. The Calapooia River flows through a narrow valley surrounded by the steep slopes of the western Cascade Mountains. The gradient of the Calapooia River through this section increases from 0.44% at the beginning of forest land to 1.94% where the North Fork Calapooia joins the river. This portion of the subbasin has the highest proportion of steep headwater tributary streams. Many of these high gradient stream channels transport debris torrents during flood events, depositing logs and gravels in the river (Weyerhaeuser 1998).

The greatest diversity of fish species is found in the lower Calapooia River subbasin. The most abundant fish species are non-salmonids, both native and non-native. Fish such as three-spine stickleback, redside shiner, and various suckers are more numerous than trout or salmon. In the upper subbasin, salmonids are the most abundant species and non-salmonids are less common.

While the lower river has relatively fewer salmonids throughout the year, it is an essential area for salmon, trout, and other species during part of their life cycle. The lower river is important as a migration corridor for anadromous winter steelhead, spring Chinook salmon, and Pacific lamprey. Winter steelhead and spring Chinook salmon must pass through the river in the lower and middle portions of the subbasin to reach spawning grounds in the upper subbasin. In addition, the tributary streams provide important rearing and high-flow sanctuary habitat during the winter and spring for juvenile salmonid species, including spring Chinook salmon and winter steelhead.

The City of Albany funded a study in which ODFW surveyed streams within, and adjacent to, the city to document fish presence. In addition to native fish species, fish populations in the lower Calapooia River include nonnative fish in the river up to the City of Brownsville (RM 30), in the lower portions of tributary streams such as Lake Creek, Butte Creek, and Cochran Creek, and in Shedd, Walton and Wright sloughs. Non-native fish species were found in most streams, including Oak Creek. Largemouth bass, smallmouth bass, bluegill, western mosquito fish, yellow bullhead, and brown bullhead were all found in Oak Creek and elsewhere.

4.4.2 Current Status of Anadromous Salmonids within the Calapooia Subbasin

4.4.2.1 UWR Chinook Salmon

Spawning surveys in the 1960s and 1970s indicated that very few spring Chinook were returning to the Calapooia River. The 1969 to 1974 average run size was estimated to be 18 fish, and in 1975 and 1976 no redds were found (Wevers et al. 1992). By the 1970s the Calapooia River population of spring Chinook probably was no longer viable (CWC 2004). Blocked fish passage, timber harvest, and urban and rural development within the subbasin have all contributed to the degradation of habitat and of local population viability. Adult fish passage problems at small dams on the Calapooia River has been a major contributing factor to the likely extirpation (and lack of success in restoration) of spring Chinook salmon (Wevers et al. 1992). Since the 1970s, hatchery spring Chinook (from the South Santiam River) have been released to reestablish naturally reproducing populations. In addition, fish straying from other Willamette tributary populations are probably entering the Calapooia River at some unknown rate.

Presently, most of the naturally producing spring Chinook spawn in the upper river above the Weyerhaeuser property boundary (RM 50). Adults must hold over the summer in pools. Spawning can begin in late August and peaks in September extending into October.

Since 1996, ODFW has been conducting annual counts of spring Chinook adults, redds, and juveniles in the upper Calapooia River. Adult and juvenile counts are done in August and redd counts are completed in September. In August 2002, 19.8 miles were surveyed and 35 adults were observed (Figure 4.4-2). Adult counts range from a maximum of 66 fish in 2001 to a minimum of 10 fish in 1997. In a survey conducted in 1971, 13 adult fish were counted.

Counts of spring Chinook redds have varied widely, ranging from a maximum of over 5 redds per mile in 1998 to a minimum of nearly 1 redd per mile in 2001 (Figure 4.4-3). There is also considerable variation in the number of rearing juveniles observed during snorkeling surveys (Figure 4.4-4). Juvenile counts are usually very low, with one to seven fish observed in most years and no fish observed in 1996. In 2001, however, an estimated 1,765 juvenile spring Chinook were observed. These high numbers may be from successful natural spawning of the 371 adults stocked in the Calapooia River during the prior year.

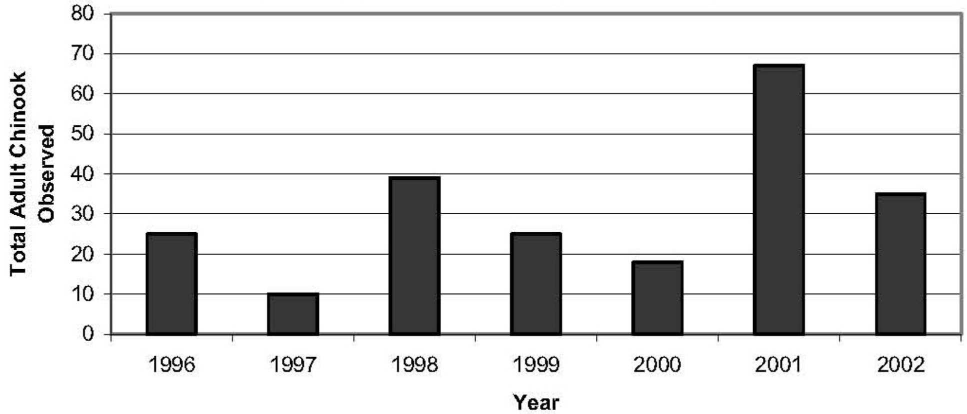


Figure 4.4-2 Annual snorkel counts of adult UWR Chinook in the upper Calapooia River, 1996-2002 (source: CWC 2004).

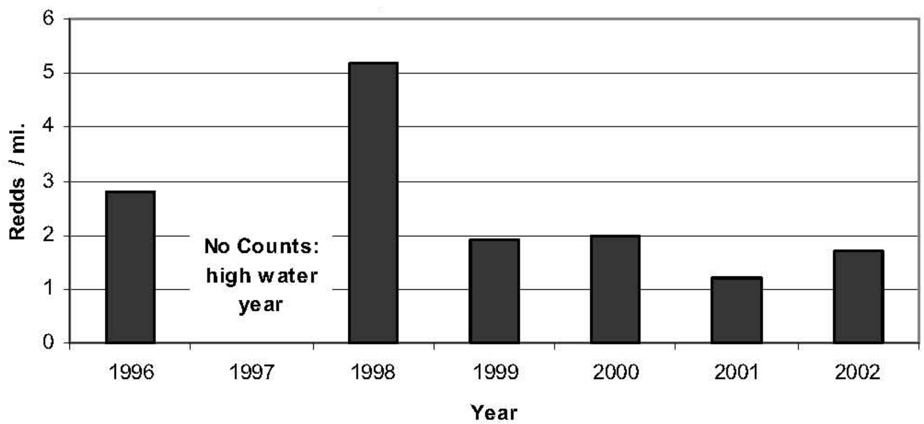


Figure 4.4-3 Annual densities (number/mile) for UWR Chinook redds counted in the upper Calapooia River, 1996-2002 (source: CWC 2004).

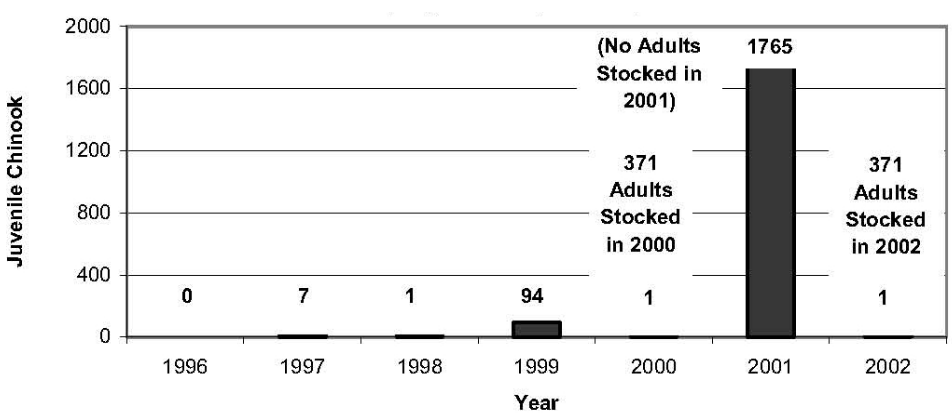


Figure 4.4-4 Annual snorkel counts of juvenile UWR Chinook in the upper Calapooia River, 1996-2002 (source: CWC 2004).

Variation in the observed numbers of juveniles in the Calapooia River may be due to young spring Chinook leaving the system to rear further downstream. ODFW has observed a range of ages for juvenile spring Chinook migration in the Willamette Basin (Schroeder et al. 2002). Fry (age 0) migrate in the late winter through early spring; fingerlings (age 0+) migrate in the fall; and yearling smolts (age 1+) migrate in early spring.

Because adult spring Chinook hold in the upper Calapooia River over the summer months, they have specific habitat needs and they are vulnerable to poaching and harassment. Spring Chinook prefer cool, deep pool habitat with abundant large wood and undercut banks for cover. Juvenile spring Chinook may spend considerable time rearing in the Calapooia River. Juvenile spring Chinook require cold water, and deep pools for feeding and cover from predators. Access to side channels, backwater areas, and tributary streams for refuge during high flows in the winter and spring is also important.

ODFW has developed objectives for recovering the Calapooia River spring Chinook population. The long-term objective (2020) is 650 adults returning to the subbasin; the interim objective (2006) is for 100 returning adults. In 2002, 35 returning adults were counted (CWC 2004).

4.4.2.2 UWR Steelhead

ODFW has been conducting annual winter steelhead spawning surveys in the upper Calapooia River subbasin since 1985. Most of the spawning surveys take place in May. While the spawning surveys do not look at the entire length of suitable spawning habitat, they do cover most of the high quality spawning areas. Since 2000, the spawning surveys have covered 7.5 miles of habitat in the Calapooia River channel and the lower portions of key tributary streams including the following.

- Calapooia River: River miles 65 to 72.5
- North Fork Calapooia River: The lower 1 mile
- Potts Creek: The lower 1 mile

Counts of winter steelhead redds have varied widely, ranging from a high of over 16 redds per mile in 1985 to a low of 1 redd per mile in 1996 (Figure 4.4-5). The variation in redd counts in the upper Calapooia River subbasin generally follow the trends for adult winter steelhead fish counted at Willamette Falls (Figure 4.4-6).

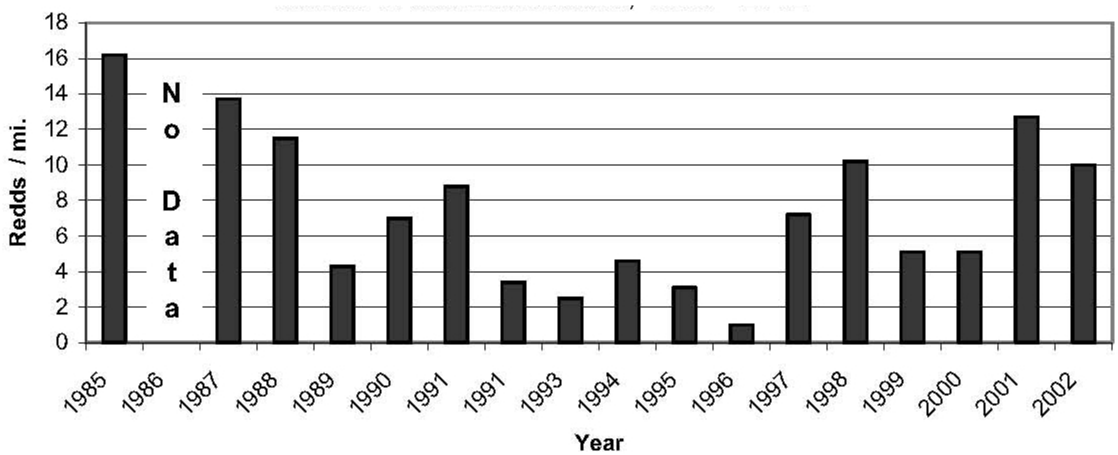


Figure 4.4-5 Annual densities (number/mile) of steelhead redds counted in index areas within the Calapooia subbasin, 1985-2002 (source: CWC 2004).

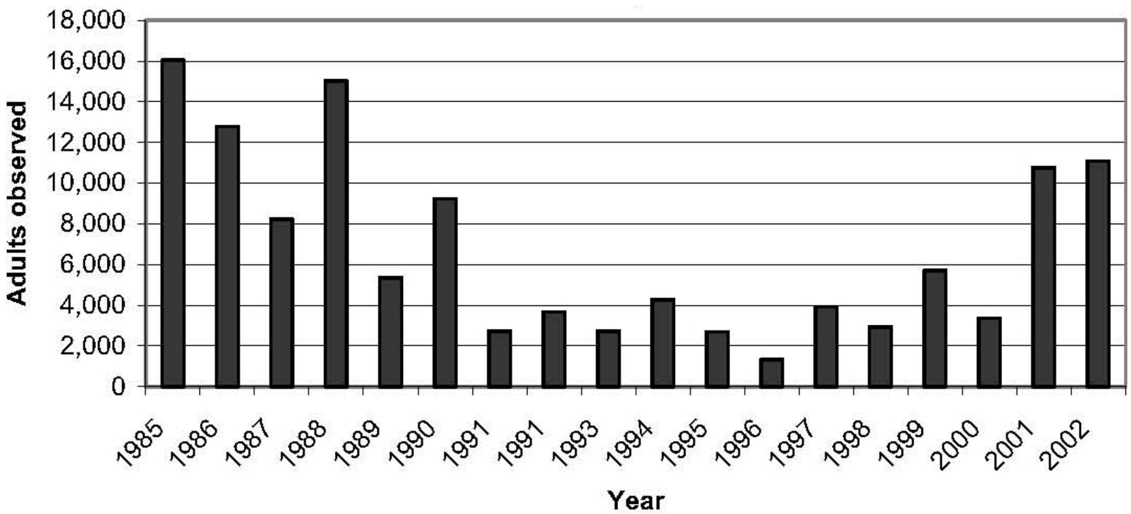


Figure 4.4-6 Annual counts of UWR Steelhead passing Willamette Falls, 1985-2002 (source:CWC 2004).

Juvenile winter steelhead typically spend two or more years rearing in the Calapooia River and its tributary streams before moving downstream to the ocean (Wevers et al. 1992). They require cold water, and deep pools for feeding and for shelter from predators. These habitat features are present in the upper subbasin. Access to tributary streams is also important to escape high water temperatures in the summer and to find refuge from high flows during the winter. Spring Chinook salmon require larger river habitat which is more degraded than habitat used by winter steelhead in the Calapooia subbasin.

The Oregon Department of Fish and Wildlife has developed objectives for recovering the Calapooia River winter steelhead population (Wevers et al. 1992). The long-term objective by year 2020 is 1,170 adults returning to the subbasin (25 redds per mile); the interim objective by year 2006 is for 15 redds per mile (Wevers et al. 1992). Since 1997 the redd counts have averaged about 7 redds per mile.

ODFW's Fish Management Plan covering the Calapooia River Subbasin (Wevers et al. 1992) identified protection, restoration, and enhancement of habitat and improved adult fish passage at Thompson's Mill and Brownsville dams as key components in their recovery strategy for spring Chinook salmon. Brownsville Dam (RM 36) was recently removed and is, therefore, no longer a concern. Habitat located in the area between the towns of Holley and Dollar (RM 46-56) was identified as an area of emphasis. Screening of the Brownsville irrigation diversion was also identified as an important action. The outplanting of hatchery fish will be necessary to reestablish a naturally reproducing local population, which should become a naturally self sustaining population upon the completion of necessary fish passage and habitat improvements.

4.4.2.3 Factors Limiting Productivity

The limiting factors and threats currently inhibiting the survival and recovery of spring Chinook salmon and winter steelhead in the Calapooia River subbasin, as identified in the Draft Willamette Chinook and Steelhead Recovery Plan (ODFW 2007b), are shown in Table 4.4-1. Even though the limiting factors and threats are broken into two groups (i.e., key and secondary), the secondary factors are important to address as well as the primary key factors.

Table 4.4-1 Key and Secondary Limiting Factors and Threats to Recovery of Calapooia Spring Chinook and Winter Steelhead.

		Tributaries (Streams and Rivers within Population Area)									West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
Threats	Species	Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook								3					4a			
	Steelhead														4a		
Hydropower/ Flood Control	Chinook											10d		5a,5b,7h,10f 9j			
	Steelhead											10d	10c		5a,5b,7h,10f 9j		
Landuse	Chinook	7a		8a	9a 8a 10b	8a		8b 9c 2h			8a	8a		5a 6e,8a,9a,9h,9i			
	Steelhead	7a		9a 10b 2a		8a		2h				8a			5a 6e,8a,9a,9h,9i		
Introduced Species	Chinook																
	Steelhead																

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

2h Impaired access to habitat above Calapooia dams.

3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.

5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.

5b Increased microdetrital inputs due to reservoirs.

7h Impaired fine sediment recruitment due to dam blockage.

8a Impaired physical habitat from past and/or present land use practices.

8b Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.

9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.

9c Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.

10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.

10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.

2h Impaired access to habitat above Calapooia dams.

4a Competition with hatchery fish of all species.

6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.

7a Fine sediment in spawning gravel from past and/or present land use practices.

8a Impaired physical habitat from past and/or present land use practices.

9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.

9h Toxicity due to agricultural practices.

9i Toxicity due to urban and industrial practices.

9j Elevated water temperatures due to reservoir heating.

10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.

10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

4.4.3 Structures Impeding Fish Passage

Impediments to fish passage can limit access to important areas for spawning or to cool tributary streams when the mainstem Calapooia River or its tributaries warm during the summer months. Fish passage impediments on the mainstem Calapooia River and its tributary streams are an issue affecting fish production throughout the subbasin. There are several dams and diversions that limit upstream migration. The dams and diversions within the Thompson's Mill complex (RM 19.5 to 28.5) cause delay and blockage of upstream migration and injury and mortality to downstream migrants, as described in detail in section 4.4.3.1 below. (CWC 2004). Brownsville Dam (RM 36) was recently removed, substantially improving fish passage from the lower to the middle part of the Calapooia River subbasin. There are numerous unscreened small diversions within the subbasin (WRI 2004).

The mainstem Calapooia River, in comparison to tributary streams, provides most of the important fish habitat, particularly for spring Chinook salmon and winter steelhead. The mainstem of the river is the primary corridor for migrating fish and it provides most of the important spawning and rearing habitat. The river's dams – within the Thompson's Mill complex – delay fish moving upstream to spawning areas in the upper subbasin and may prevent the movement of adult and juvenile fish during parts of the year. Delaying the migration of spring Chinook and winter steelhead stresses the fish, leading to reduced spawning success, and provides opportunities for poaching and harassment.

Road crossings and culverts also present a problem for salmon and steelhead in the Calapooia subbasin. Fish passage at road crossings is important for providing access for adult salmon, trout and steelhead to spawning areas and for providing access for juvenile fish to escape unfavorable conditions such as warm water temperatures in the summer and high flows in the winter. Juvenile winter steelhead and spring Chinook salmon use the lower portions of seasonally intermittent and perennial tributary streams.

4.4.3.1 Lower Calapooia Subbasin

Fish passage has been assessed for dams along the lower Calapooia River corridor, but there are no comprehensive inventories of fish passage barriers for tributary streams. Some road crossings have been assessed through an inventory conducted in upper Courtney Creek and the middle portions of the subbasin (Brush, Pugh, and other tributaries).

Migrating fish encounter significant passage impediments between river mile 19.5 and 28.5 of the Calapooia River. At this location, there is a complex of dams and diversion ditches associated with Thompson's Mills (Figure 4.4-7). Historically, water was diverted through the Mill for producing flour and for generating electricity. In the late 1990s after UWR Chinook salmon and UWR steelhead were listed under the ESA, the Mill owner began working with Federal and State agencies to find a solution to fish passage problems without shutting down this historically valuable mill. The Thompson's Mills Working Group was formed to identify options for addressing fish passage problems and to explore ways of preserving the historical site. Part of the solution was for Oregon Parks and Recreation Department (OPRD) to purchase the property, including rights to water use and hydropower generation. The sale of Thompson's Mills project took place on March 18, 2004 (OPRD filed the License Assignment with the Federal Energy Regulatory Commission on August 2, 2006). Subsequently, on February 27, 2008, OPRD filed an application with FERC to surrender the FERC license to generate commercial hydropower and that application stated that OPRD ceased power production in 2005. The OPRD is interested in preserving the mill in its historic condition as an operating grain mill, so they retain an interest in diverting smaller and less frequent amounts of flow for this purpose. The working group continues to work with OPRD to develop permanent solutions for the relic diversion structures, which are not needed for the demonstration of the grain mill.

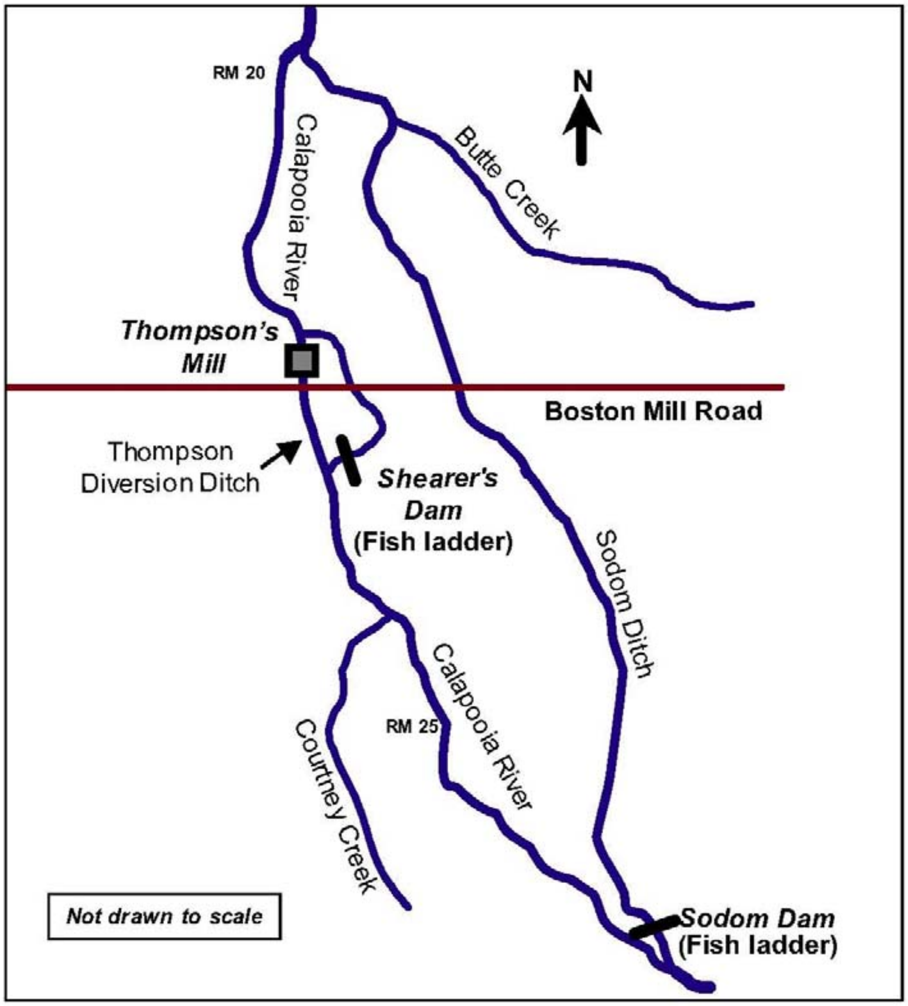


Figure 4.4-7 Dams and diversion ditches associated with Thompson's Mill that cause significant fish passage problems on the Calapooia River between Mile 19.5 and Mile 28.5.

Currently, water is diverted for purposes of demonstration of milling techniques. A series of dams (Sodom and Shear Dams) and ditches (Sodom and Thompson Diversion ditches), divert the Calapooia River's flow, creating problems for migrating fish. These diversions allow OPRD to operate Thompson's Mills with water diverted by Sodom Dam and Shear Dam (labeled Thompson Dam on the Halsey USGS Quadrangle map). Sodom Diversion ditch was built as a high water diversion for the purposes of diverting high stream flows away from the mill and a ten-mile stretch of river downstream. Unfortunately, it was too effective and in 1890, Sodom Dam was built to help divert river water out of the ditch and back into the Calapooia River. Shear Dam diverts water from the Calapooia River into the mill race.

The primary difficulties that the aforementioned fish passage obstacles pose for UWR Chinook salmon and UWR Steelhead, as well as other fish species, are described below:

Fish Passage at the Dams

Fish encounter problems moving over Sodom (about 11 feet high) and Shear dams (about 5 feet high). During late winter and early spring high flows, more water passes through Sodom Ditch and is diverted away from the Mill, reducing flow through the mainstem Calapooia River channel. Migrating winter steelhead move through Sodom Ditch and pass over the fish ladder at Sodom Dam. In addition to delaying upstream migration of winter steelhead, the dam presents significant obstacles to UWR Chinook salmon as they must pass over in the late spring when river flows have dropped. Water flowing over the dam creates velocities that attract adult UWR Chinook salmon to the base of the dam and outcompete the fishway flows, which attracts fish away from the fish ladder and inhibits efficient passage. As a result, UWR Chinook salmon will hold for a period of time in the pool at the base of the dam, delaying their migration to spawning locations in the upper subbasin, making the delayed fish vulnerable to harassment and poaching. In addition, the fishway does not meet current requirements for passage and provides inadequate passage conditions. In addition to all of these concerns, Sodom Dam fishway is likely to fail at some point as the fishway is in poor structural condition. The concrete is no longer watertight and deterioration is occurring rapidly. If this occurs, then a complete passage barrier will occur. The Shear Dam fishway does not meet current requirements for fish passage and provides inadequate fish passage conditions.

Steelhead Spawning in Sodom Ditch

Winter steelhead, as well as Pacific lamprey, have been observed spawning in Sodom Ditch. Suitable spawning gravels are also present in the river reaches immediately upstream. The diversions of significant river flows into Sodom Ditch have led to a situation where the habitat and flows may attract winter steelhead. However, spawning in Sodom ditch may be attributed to delay of fish passage at Sodom Dam. Spawning in the ditch is a concern because the juvenile winter steelhead probably do not survive the high summer water temperatures in this reach of the river (ODFW 2004a).

Calapooia River Channel

During the winter and spring high flow periods, most of the Calapooia River's discharge flows through Sodom Ditch. This dramatic reduction in high flows moving through the Calapooia River has changed the river channel and associated floodplain within this reach of the river. The river channel has narrowed and, because there is reduced flooding, homes have been built in the historic floodplain. With these changes, there are limited alternatives for increasing high flows through the Calapooia River channel. Sodom Dam is identified as major factor for interruption of Calapooia river gravel transport. The Thompson's Mill Working Group is examining alternative water allocation through the river channel and Sodom Ditch and the implications for fish migration, aquatic habitat, geomorphology, and future operation of the Mill.

To help understand and identify fish passage solutions and options for future operation of the Mill, the Working Group has collected information on fish habitat within the river and on diversion ditches; tracked fish holding patterns and movement through the complex and over the dams; monitored water temperatures; and measured water flow rates in the river and ditches. In addition, the Working Group has developed a water distribution model that will identify options for allocation of water through the river channel and diversion ditches. The Working Group will be completing a plan for water management and fish passage improvements to OPRD by 2009, but there is no certainty that OPRD will have funds to carry out the Group's recommendations.

4.4.3.2 Middle Calapooia Subbasin

Fish passage issues have been examined at the Brownsville Dam and on selected tributary streams in the middle Calapooia River subbasin. Brownsville Dam was removed in 2007 eliminating fish passage problems on the mainstem Calapooia River associated with that structure.

Fish Passage Barriers on Tributary Streams
Potential fish passage barriers were assessed for most of the tributary streams in the middle Calapooia River subbasin and middle and upper reaches of Courtney Creek in the spring of 2003. Over 80 road crossings were inventoried on county, federal, and private lands (CWC 2004). The culverts were evaluated for their ability to provide fish passage based on criteria developed by ODFW. A majority of the evaluated crossings in the subbasin do not meet these fish passage criteria.

In addition to culverts at road crossings on tributaries in the middle Calapooia River subbasin and Courtney Creek, there is a private water diversion dam on the West Fork of Brush Creek. Although this dam has not been inventoried for fish passage, it is probably a barrier to fish movement.

4.4.3.3 Upper Calapooia Subbasin

In comparison to the lower and middle subbasin areas, fish passage is not a significant issue in the upper Calapooia River subbasin. There are no dams in the mainstem river channel. Weyerhaeuser and the Forest Service have inventoried culverts in the upper subbasin for fish passage at road crossings. Many culverts were replaced after the 1996 flood, and Weyerhaeuser has corrected most of the identified fish passage problems in the streams identified to have the highest quality habitat (CWC 2004).

4.4.4 Hatchery Program

In the past, South Santiam stock spring Chinook salmon from South Santiam hatchery were sporadically outplanted in the Calapooia River to bolster natural production in the population because of the extremely low number of adults returning. However, ODFW last released hatchery fish into the Calapooia River in 2003, and the fish that are naturally reproducing in this subbasin are largely offspring of hatchery releases from previous generations (although some native Calapooia genetic material may still be present if native fish spawned with hatchery-origin fish). The Willamette Hatchery Mitigation Program for spring Chinook salmon may result in continuing threats and exert key adverse effects on attempts to re-establish a locally adapted, naturally reproducing, and self-sustaining population of spring Chinook salmon in the Calapooia River (ODFW 2007b). However, the potential risk of genetic introgression resulting from interbreeding is diminished now that outplanting has been discontinued.

4.4.5 Fisheries

In their draft Upper Willamette Chinook and Steelhead Recovery Plan, ODFW concluded that harvest was not a key threat at any life stage for Calapooia River steelhead or spring Chinook salmon populations (ODFW 2007b). Currently, there are no hatchery programs in the subbasin, relatively small numbers of naturally produced fish migrate from the basin each year, river harvest for spring Chinook salmon (both outside of, and within, the Willamette River Basin) has been curtailed to identifiably marked hatchery fish, and there are no directed harvest seasons for either spring Chinook salmon or winter steelhead within the Calapooia River subbasin.

4.4.5.1 Spring Chinook

In the past, there was little documented sport catch of adult spring Chinook in the Calapooia River. The average annual catch during 1963 to 1974 was 13 fish with a range of 0 to 34 fish (Wevers et al. 1992). The subbasin has been closed to spring Chinook salmon angling since 1988, although there is some evidence of continued illegal harvest (CWC 2004).

4.4.5.2 Steelhead

To protect young winter steelhead (which often cannot be distinguished from cutthroat trout), ODFW has restricted trout fishing to catch-and-release with barbless hooks. There is currently no directed harvest season for adult winter steelhead. There are winter steelhead harvest records in the Calapooia River from 1977 through 1988. During this period, the maximum catch was 122 adult fish in 1979 (Wevers et al. 1992).

4.4.6 Status of PCEs of Designated Critical Habitat and Factors Affecting those PCEs in the Calapooia River Subbasin

Natural vegetation comprises from about 25% to 70% (with a median of about 45%) of the stream corridor within 500 feet of the mainstem Calapooia River in the middle and lower parts of the subbasin (i.e., downstream of Holley). Hardwoods are the primary natural vegetation growing within 200 feet of the Calapooia River main channel. Relatively old stands consist of Oregon ash, black cottonwood, bigleaf maple, and red alder occurring in combination. Younger hardwood stands are relatively scarce.

An evaluation by Weyerhaeuser (1998) of riparian conditions on forest land in the upper subbasin along the main channel of the Calapooia River and other fish-bearing tributaries (55 miles total) indicates that a majority of riparian zones (64%) are bordered by vegetation that has low near-term potential for providing large wood to the river channel. Only 14% of areas surveyed were bordered by stands that had a high potential for providing large wood in the near term.

Because the main channel of the Calapooia River is so wide (75 to 100 feet in most reaches) even the tallest trees along the river provide little shade during the summer. On forest land in the upper subbasin, low amounts of shading (less than 40%) on the main channel persist up to the North Fork Calapooia River confluence (Weyerhaeuser 1998). Upstream of this confluence the river is narrow, and shading levels alternate between moderate (40-70%) and high (>70%).

There are no comprehensive assessments of aquatic habitat for all of the river channel and tributary streams in the lower Calapooia River subbasin. ODFW has assessed aquatic habitat for the portion of the river channel within the Thompson's Mill complex and the diversion ditches (ODFW 2004a).

The lower Calapooia River subbasin is used by anadromous fish for migration and rearing. Aerial photo interpretation of the lower river channel and riparian areas provides some insights into fish habitat features (CWC 2004). Based on this analysis, the Calapooia River channel has the highest sinuosity downstream of Sodom Ditch. Channels with high sinuosity contain habitat features that are favorable for fish, including ponds, islands, alcoves, side channels, and gravel bars. Natural ponds, side channels and tributary streams in the lower Calapooia River subbasin provide important habitat for a number of fish. Salmon and steelhead juveniles use these areas as a "refuge" from high water flow velocities in the main river channel during reoccurring flooding periods during the winter and early spring. Although there is very little information documenting the loss of off-channel habitats in the lower Calapooia River subbasin, these habitats have probably been lost through various activities, including rip-rap armoring of stream banks, filling wetlands, and construction of fish passage barriers that disconnect tributary streams and sloughs from the river.

ODFW has inventoried stream habitat for the river above Holley. In addition, ODFW has examined fish habitat for the river between Holley and the Sodom Dam. An aerial photo interpretation of the river channel and riparian areas provides some information on fish habitat features in the middle portion of the subbasin (CWC 2004). Based on this analysis, the Calapooia River channel in the middle portion of its subbasin still has considerable sinuosity. In the upper part of this area, the channel is less sinuous and is constrained by areas of bedrock. The river channel from Sodom Ditch diversion to Brownsville Dam has the greatest amounts of gravel deposition. Since this is a depositional area, large trees and logs in the channel would help to create pools and diverse fish habitats.

There are no comprehensive assessments of stream habitat for tributary streams in the middle portion of the Calapooia River subbasin. The lower reaches of the tributary streams provide important high-flow sanctuary and winter rearing areas for spring Chinook salmon and for winter steelhead.

The upper Calapooia River subbasin includes the river channel and tributary streams in the forest lands above Holley. The river in this section flows through the Western Cascade Mountains with a narrow valley often paralleled by a road. There are numerous tributary streams, many with high gradient channels. Salmonid species are the most common fish found in this part of the subbasin. The upper subbasin is the key area for spring Chinook salmon and winter steelhead spawning and juvenile rearing because of the relatively high quality of available habitat in this area. As a result, it is important to improve access to this area to achieve protection and recovery of these ESA listed species. Cutthroat trout and mountain whitefish are also common in this area.

In 1991, ODFW completed aquatic habitat inventories for the river and important tributaries in the upper Calapooia River subbasin. The inventories covered the upper Calapooia River (three reaches), the North Fork (one reach), and Potts Creek (three reaches). The inventories used

ODFW's standard methods, which focus on collecting data on key fish habitat features, including active channel width, number of pools, pool depth, gravels, and pieces of large wood.

With the exception of Reach 3 in the Calapooia River, all of the river reaches have very few pieces of large wood (greater than 30 feet long and 24-inches in diameter). There was no large wood found in Potts Creek and the North Fork Calapooia. Significantly, all of the inventoried reaches had low to moderate pool numbers and percentages of area in pools. Pool areas of more than 25% are an indication of high quality habitat. Potts Creek was the only inventoried stream with pool areas exceeding 25%.

The ODFW inventory was completed before the 1996 flood. The 1996 flood event created a number of landslides and debris torrent in the upper Calapooia River subbasin. Many of these torrents delivered wood to the lower portions of tributary streams and the river channel (Weyerhaeuser 1998). As a result, there is probably more wood in the river and stream channels than is reflected in the 1991 surveys. A separate aquatic habitat inventory was completed for the Calapooia River on Forest Service Land in 1998. The lower portions of the Forest Service inventory overlapped Reach 3 of the ODFW inventory. The 1998 inventory found large numbers of wood pieces in the river, much of it in large log jams that were delivered in the 1996 flood (CWC 2004). Significantly, many of these large log jams created side channels. Side channels create high quality fish habitat by providing backwater areas for fish feeding and refuge from high flows.

Suitably sized gravel in riffle areas is an indication of potential spawning habitat for winter steelhead, spring Chinook, and cutthroat trout. Riffle gravels ranged from 13% to 45% of habitat area in reaches surveyed in the upper Calapooia River subbasin, with 30% or more indication relatively high quality spawning habitat according to ODFW criteria. About half (50.33%) of the 33.2 miles surveyed contained areas of high quality for spawning. To improve habitat, Weyerhaeuser has added large wood to the channel in the North Fork to increase wood volumes, create pools, and capture spawning gravels (CWC 2004).

Historically, there were frequent and large log drives down the lower Calapooia River. These log drives and the associated removal of wood and log jams, probably continue to affect the river channel by limiting the current quantity of wood in the channel. The reduced number of logs and other wood in the river's channel limit the creation of pools and rearing or holding habitat for fish. Large sediment loads resulting from bank failures associated with timber harvest have resulted in siltation and compaction of spawning gravels in some areas.

The loss of wood from the river channel is further exacerbated by current wood removal. Logs continue to be removed from the Calapooia River and tributary streams. Logs are removed to prevent bank erosion, reduce damage to property and bridges, and, in some cases, to allow recreational boaters to pass down the channel (CWC 2004). In addition, the lack of large trees growing along some sections of the river and streams contributes to the long-term shortage of wood in channels. The status of streamside forests and the wood removal actions have cumulatively impacted the river channel and fish habitat quality, reducing the formation of pools, limiting hiding cover, and slowing the trapping of spawning gravels.

Conclusions

In summary, present or historical land use practices exert key adverse effects on juvenile life history stages of the Calapooia winter steelhead and spring Chinook populations in the Calapooia subbasin (ODFW 2007b). Land use impacts also exert key adverse effects on the adult life stage of Chinook in the Calapooia basin. Limiting factors in the Calapooia basin include:

Water Quality

Naturally low flows in the basin are aggravated by water withdrawals, which increase water temperatures. Water temperatures exceed criteria in the Calapooia River and some tributaries, particularly in the lower subbasin. In general, water temperatures are lower in the forested upper subbasin than in the lower subbasin (CWC 2004). Elevated water temperatures decrease survival and/or growth of juvenile Chinook, as well as increase prespawning mortality of adult Chinook.

Long-term monitoring of bacteria in the Calapooia River at the Queen Avenue Bridge (in Albany downstream of Oak Creek) by the Oregon Department of Environmental Quality has indicated chronic high levels of E. coli (CWC 2004).

Physical Habitat Quality

Modifications to key habitats and the natural processes that form and maintain them have affected all life stages of fish. Impaired physical habitat particularly reduces rearing potential for Chinook and steelhead winter parr. Loss of holding pools causes increased prespawning mortality of adult Chinook. Habitat quality has declined through changes in interactions between stream systems and their floodplain that have reduced the delivery and transport of large wood, modified gravel deposition, reduced the frequency and depth of pools, minimized hiding cover for adult and juvenile fish, and reduced available spawning areas. Flow modifications and channel confinement and in-stream barriers have reduced access to off-channel habitats essential for juvenile rearing and winter refuge and decreased connectivity between habitats throughout the subbasin and the dynamic processes needed to form and maintain habitat diversity (WRI 2004).

NMFS determined that the following occupied areas of the Calapooia subbasin contain Critical Habitat for UWR Chinook salmon or UWR steelhead (NMFS 2005IV; maps are included in Section 3.3 of this opinion):

UWR Chinook (spring-run)

- Two watersheds contain UWR Chinook habitat in the Calapooia subbasin. This habitat, all found in the mainstem Calapooia River (and Sodom Ditch) provides 36.4 miles of PCEs for spawning/rearing, 42.3 miles for rearing/migration, and 0 miles for migration/presence (NMFS 2005VII).
- The Calapooia River watershed (HUC 1709000303) was rated as being of moderate importance to the conservation of the ESU and provides 36.4 miles of PCEs for spawning/rearing and 24.9 miles of PCEs for rearing/migration (NMFS 2005VII).
- The Oak Creek watershed (HUC 1709000304) contains the lower 17.4 miles of the Calapooia River, which are rearing/migration habitat for UWR Chinook (NMFS 2005VII).

UWR Steelhead

- Two watersheds contain UWR steelhead habitat in the Calapooia subbasin. This habitat, found in the mainstem Calapooia River, Sodom Ditch, and multiple tributaries, provides 56.3 miles of PCEs for spawning / rearing, 33.8 miles for rearing/migration (NMFS 2005VII)..
- The Calapooia River watershed (HUC 1709000303) was rated as being of high importance to the conservation of the ESU and contains 56.3 miles of PCEs for spawning/rearing and 16.4 miles of PCEs for rearing/migration (NMFS 2005VII).
- The Oak Creek watershed (HUC 1709000304) provides 17.4 miles of rearing/migration habitat for UWR steelhead (NMFS 2005VIII).

NMFS (2005g) identified the key management activities that affect these PCEs. Key management activities include forestry, dams, road building and maintenance, channel modifications/diking, and agriculture.

Table 4.4-2 summarizes the condition of PCEs within the Calapooia River. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most cases, this is primarily the result of human activities (e.g., development, agriculture, and logging).

Table 4.4-2 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for the Calapooia River subbasin under the environmental baseline.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Lower Calapooia subbasin* The Thompson's Mill complex of dams and diversion ditches (RM 19.5 to 28.5) delays and partially blocks UWR Chinook salmon and UWR steelhead upstream migration, leaving fish vulnerable to harassment and poaching. Sodom Dam fishway is rapidly deteriorating, and if it fails, will cause a complete passage barrier.	Non-federally owned dams

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Middle Calapooia subbasin* The Calapooia subbasin Council identified high priority opportunities to correct fish passage problems associated with road crossings and culverts at about 80 locations. Most culverts in small streams with high gradients were on forest lands. Many of the forest landowners in the subbasin have replaced culverts with installations that provide for fish passage. Highest priority culverts for improvement of fish passage were identified. These culverts are on county, BLM and private lands. Most of the identified culverts are in streams that are in the lower portions of the subbasin and have significant fish habitat above the culvert. Because the culverts have excessive jump heights, many of these culverts are barriers to adult fish movement and prevent use of these areas as high-flow sanctuary and overwinter rearing habitat by juvenile UWR Chinook salmon and steelhead. Numerous unscreened small diversions within the subbasin affect juvenile UWR Chinook salmon and steelhead. A private water diversion dam on the West Fork of Brush Creek is probably a barrier to upstream fish movement.	Private land management and lumber operations Private, local government, and federal land management Agriculture on private lands

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Mainstem Calapooia River flows have been altered as a result of dams constructed primarily in the lower part of the subbasin. Brownsville Dam was removed in 2007, restoring more normative hydrologic function to the mainstem channel in the upper part of the lower subbasin area. The Thompson's Mill complex of dams and diversions still impacts hydrology in the lower subbasin area, resulting in reduced floodplain connectivity, reduced sediment and gravel transport, and in channel and habitat simplification. Naturally low flows in the basin are aggravated by water withdrawals.	Privately owned dams Agricultural, urban, and rural development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Decreased flow in Sodom Ditch in the summer when Thompson's Mills takes water down the Calapooia results in increased water temperatures in the Ditch when UWR steelhead fry would be rearing. The ODEQ 2004/2006 Integrated Report database indicates that the Calapooia River and at least three associated water bodies, Brush Creek, Sodom Ditch, and the North Fork Calapooia River, exceed state water quality criteria for temperature. Removal of riparian forest and other effects of development contributing to elevated summer water temperature, particularly in the lower part of the Calapooia subbasin, decrease survival and/or growth of juvenile UWR Chinook salmon and increase prespawning mortality of adult Chinook.	Private hydropower production Agricultural and private development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	The ODEQ 2004/2006 Integrated Report database does not report any streams as water quality limited due to turbidity in the Calapooia subbasin.	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Monitoring of bacteria in the Calapooia River at the Queen Avenue Bridge in Albany (downstream of Oak Creek and near the mouth) by ODEQ has indicated chronic high levels of E. coli. However, the ODEQ 2004/2006 Integrated Report database suggests that high bacteria levels are not common above Oak Creek.	Urban and rural development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database indicates that the lower 31.2 miles of the Calapooia River are water quality limited for dissolved oxygen during the late winter and spring spawning period (ODEQ 2006b).	May be related to causes of nitrification and elevated temperatures

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the Calapooia subbasin were water quality limited due to excess TDG measurements	N/A
Freshwater spawning sites	Habitat Elements	Substrate	The channel downstream of the Thompson's Mill complex dams may have coarsened and could lack spawning gravel. About half (50.33%) of 33.2 miles surveyed in the upper subbasin contained gravel bars providing relatively high quality spawning habitat. Large sediment loads resulting from bank failures associated with timber harvest have resulted in siltation and compaction of spawning gravels in some areas.	Privately owned dams Timber harvest

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Large wood is blocked from access into the lower Calapooia River from about 65% of the subbasin by the Thompson's Mill complex. The Calapooia subbasin lacks large wood in most stream channel areas of the basin except for parts of the upper mainstem. Logs continue to be removed from the Calapooia River and tributary streams to prevent bank erosion, reduce damage to property and bridges, and to allow recreational boaters to pass down the channel. The lack of large trees growing along some sections of the river and streams contributes to the long-term shortage of wood in channels. The status of streamside forests and wood removal from streams have cumulatively impacted the river channel and fish habitat quality, reducing the formation of pools, limiting hiding cover, and slowing the trapping of spawning gravels.	Privately owned dams Historic splash dams and log drives, snag and removal of logs and log jams. Removal of large wood by landowners and boaters for navigation and/or firewood Local development and agricultural development in the lower subbasin resulting in riparian area depletion.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Potts Creek was the only inventoried stream with high quality pool habitat (i.e., with pools exceeding 25% of total habitat area). Pool habitat is of moderate quality (ranging 21% to 24% of total habitat area) in the upper mainstem Calapooia River. Pool frequency and quality in most of the Calapooia subbasin is low due to absence of pool forming elements such as LWD and/or sediment.	Removal of LWD, downstream LWD and sediment transport blocked by private dams, roads, channel scour, land uses such as timber harvest, and diking in the middle and lower river.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Loss of off-channel habitats in the middle and lower Calapooia River subbasin have occurred as a result of rip-rap armoring of stream banks (5,605 linear feet in the middle Calapooia subbasin area), filling of wetlands, and construction of fish passage barriers that disconnect small tributary streams, side channels, and sloughs from the river channel. There is poor connectivity to off-channel habitat in lower river.	USACE and private revetments Reduction in the magnitude and frequency of peak flows as a result of private dam and diversion operations Diking, dredging, and human development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Streambanks do not support natural floodplain function in the lower half of the subbasin.	USACE and private revetments Diking, dredging, agricultural and other human development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	The floodplain is not frequently inundated, with reduced over-bank flow and side channel connectivity. Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests The lower Calapooia subbasin is disconnected from its historical floodplain by dams and diversions that have reduced peak mainstem flows and by streamside revetments.	Private dams and diversions USACE and private revetments Agricultural and residential development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Disturbance History	The disturbance regime is dominated by timber harvesting. Forests are dominated by early- to mid-successional stages, with few late-successional forests. Timber harvesting has increased sediment delivery to streams, but decreased large wood input, resulting in degraded aquatic habitat. Upper subbasin is forested, but some is managed for timber production rather than ecosystem health. Most of the subbasin (94%) is in private ownership. Lower subbasin is predominantly agricultural, urban, and residential development.	Fire suppression Timber harvesting Conversion to agricultural, urban, and rural uses

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	There has been decreased quality and extent of streamside riparian vegetation, especially in the middle and lower parts of the subbasin. Natural vegetation comprises about 45% of the stream corridor within 500 feet of the mainstem in the middle and lower parts of the subbasin. Relatively old stands of mixed hardwoods are the primary natural vegetation growing within 200 feet of the channel. The upper subbasin is more heavily forested with stands of conifers. Only 14% of areas surveyed in the upper subbasin were bordered by stands that had a high potential for providing large wood in the near term. Low amounts of shading (less than 40%) occur on the main channel of the lower and middle subbasin. In the upper subbasin, shading levels range from moderate (40-70%) to high (>70%). In the lower basin, remaining patches of floodplain forest are interspersed with agricultural and residential development. Floodplain forests along the lower river have been invaded by non-native species that hinder natural vegetative development. There has been a decrease in surface area of gravel bars for potential young riparian stand recruitment, especially in the middle and lower parts of the subbasin.	Clearing for agriculture, urban, and rural development Timber harvest Stream clean-out practices USACE and private revetments Private dams and diversions alter the hydrologic regime

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Section 4.5
South Santiam Baseline

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4.5 SOUTH SANTIAM SUBBASIN

The South Santiam River is about 63 miles long and drains an area of about 1,000 square miles with the headwaters dominated by forestlands (Figures 4.5-1). Approximately 32% of this subbasin is in public ownership, including headwaters in the Willamette National Forest (ODFW 1990b). Some land in the lower portion of the subbasin is managed by the BLM (Salem District), but most of the area that contributes flow to the river is downstream of the lower-most USACE dam (Foster) is private.

The South Santiam's headwaters are characterized by steep, forested drainages that originate on basalts and andesites (materials of volcanic origin), and then flow through narrow valleys toward the broader alluvial valley in the lower subbasin. Larger drainages above Foster Dam include the South Santiam mainstem, the Middle Fork, and Quartzville Creek. Channel slopes along the mainstem decline in the downstream direction, to approximately 0.4% between Foster Dam and Lebanon, and to less than 0.1% in the alluvial valley below. Wiley Creek joins the South Santiam immediately downstream of Foster Dam, while Crabtree and Thomas creeks enter the South Santiam near the river's confluence with the North Santiam River.

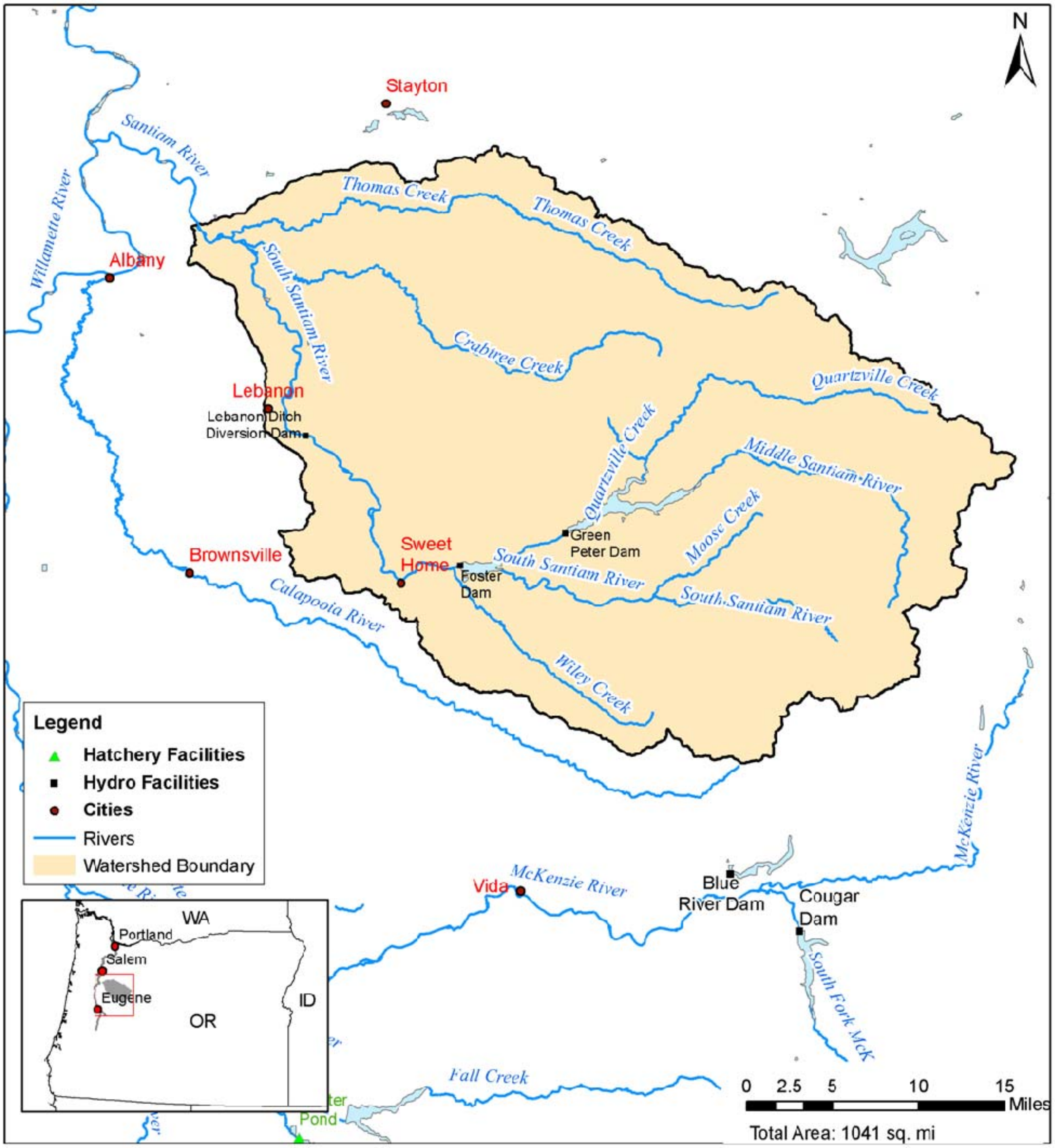


Figure 4.5-1 South Santiam Subbasin

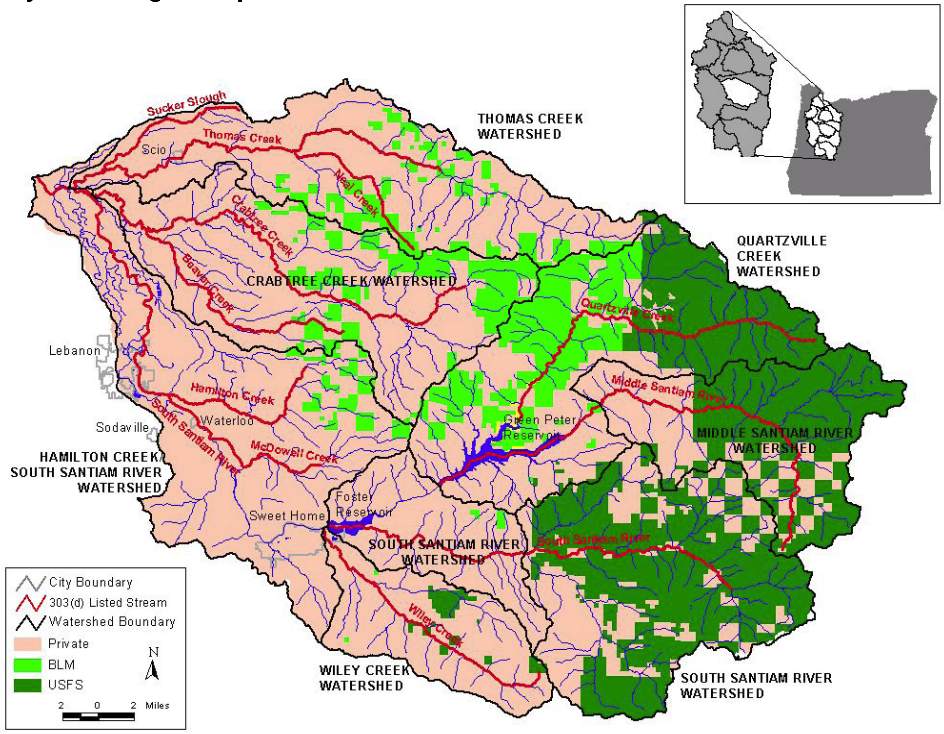
4.5.1 Historical Populations of Anadromous Fish in the South Santiam Subbasin

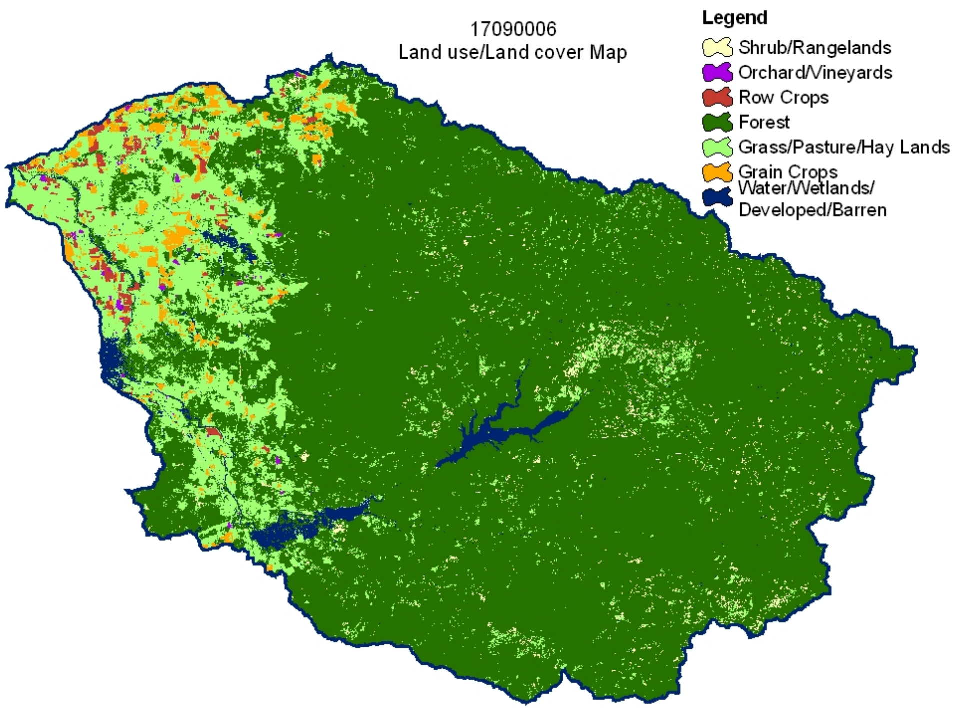
UWR Chinook salmon

UWR Chinook salmon are native to the South Santiam River and once spawned in the mainstem South Santiam, the Middle Santiam, and in all major tributaries including Wiley, Thomas, Crabtree, Quartzville, and Canyon creeks (Willis et al. 1960; Thompson et. al 1966; Fulton 1968; WNF SHRD 1995, 1996). Returns to the river had declined substantially by the mid-1900s but was still estimated to include about 1,300 spawners in 1947, with the most heavily used spawning areas located above the town of Foster (Mattson 1948). The species' access to much of the area where Mattson (1948) observed spawning during 1947 has been either blocked or impaired since completion of Foster and Green Peter dams by the USACE in 1968.

USFWS (1963) reported an annual spawning run of about 1,400 above the current site of Foster Dam. About 70% of these adult fish originated in the Middle Santiam River (above the current site of Green Peter Dam), 7% in the reach that is now under Foster Reservoir, and 23% in the South Santiam River above Foster. Thompson et al. (1966) estimated a total annual run size (natural- and hatchery-origin) of 3,700 adults during the 1960s. Estimates based on the sport catch and returns to Foster Dam indicate that the minimum total (natural plus hatchery-origin fish) run size to the subbasin during the 1970s and 1980s varied from less than 500 to nearly 10,000 per year (Chilcote 2007).

Hatchery broodstock collection efforts within the subbasin began in 1923, at a weir placed across the river near the town of Foster (Wallis 1961). The South Santiam Hatchery began operations in 1966 to mitigate for loss of Chinook salmon production in areas above Foster Dam (passage was ineffective at Foster).





Figures 4.5-1 Maps of the South Santiam subbasin (ODEQ 2006a, top) and of land use patterns within the subbasin (NRCS 2005a, bottom).

UWR Steelhead
UWR steelhead are also native to the South Santiam subbasin. These fish spawned historically in upper portions of the subbasin, above the sites of Foster and Green Peter dams, as well as in downstream tributaries (Olsen et al. 1992). No estimates of pre-1960s abundance are available for the subbasin's native winter steelhead. However, ineffective downstream passage at Foster and Green Peter Dams, and inadequate upstream passage at the latter facility are believed to have caused up to a 75% reduction in the native steelhead population in the upper subbasin over time (USACE 2000). After the dams were constructed, Buchanan et al. (1993) estimated that 2,600 winter steelhead spawned in the entire South Santiam River basin, including the upper mainstem above the dams and in Thomas, Crabtree, McDowell, Wiley, Canyon, Moose, and Soda Fork creeks.

4.5.2 Current Status of ESA-Listed Salmon and Steelhead within the Subbasin

4.5.2.1 UWR Chinook salmon

Population Viability
The South Santiam population of UWR Chinook is considered to be at very high risk of extinction, based on an analysis of its abundance, productivity, spatial structure, and diversity (McElhany et al. 2007). Chronically unfavorable conditions have influenced this risk, as does the potential for catastrophic events. WLCTRT (2003) rated the risks of catastrophic loss as high from landslides (based on geology and precipitation patterns), epidemics (due to hatchery releases), and pollution (related to roadway transportation spills).

Abundance & Productivity
In the draft viability assessment for South Santiam spring Chinook, McElhany et al. (2007) rated the population's limited abundance and productivity as posing a very high extinction risk. As described in this section, abundances of wild spawners are generally low, pre-spawn mortality rates for these fish are high, and recent use of natural spawning areas has been dominated by fish of hatchery origin (Schroeder et al. 2006).

Adult UWR Chinook returning to the South Santiam River are counted at a fish trap near the base of Foster Dam, and their redds are counted in spawning areas downriver as well as in a few tributaries. Figure 4.5-2 gives the numbers of adult fish counted in the Foster Trap each year from 1984 to 2005. During this period the returns have been strongly dominated by hatchery fish, peaked in 1990 at more than 7,000 fish, and peaked again in 2004 at more than 10,000. Returns were below average from 1992 to 1997, increased through 2004, and then decreased during 2005.

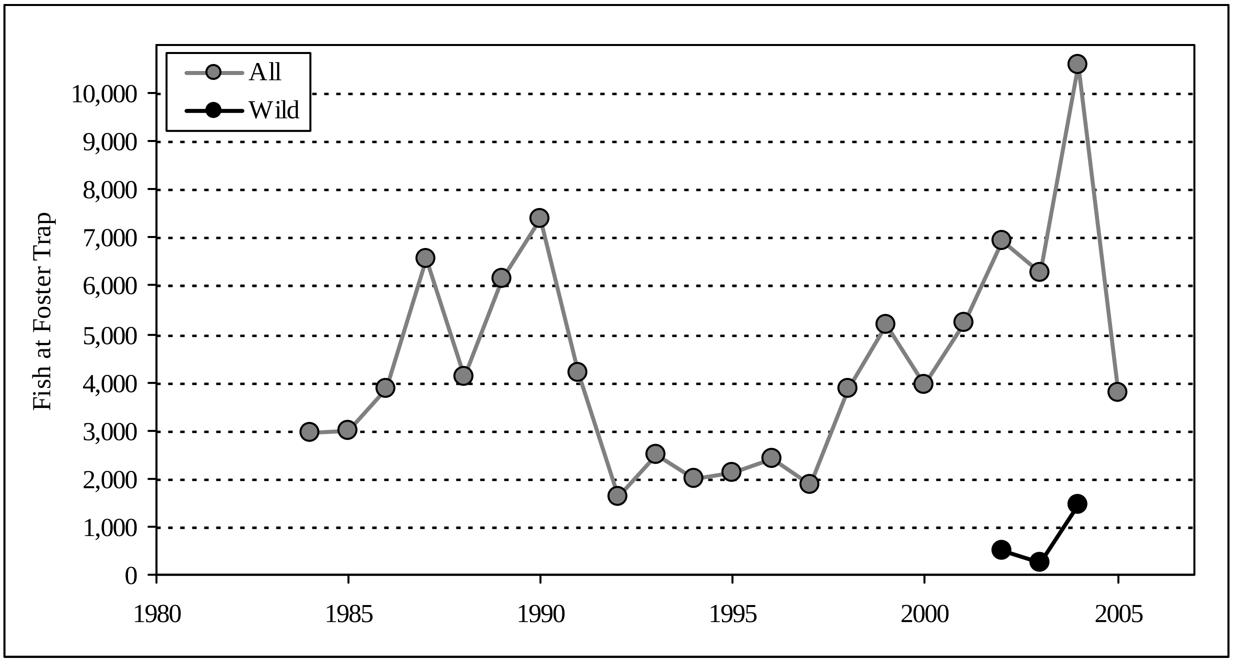


Figure 4.5-2 Annual returns of spring Chinook salmon to Foster Dam from 1984-2005 (Streamnet trend 58668), including 2002-2005 estimates of the wild component that were developed by McLaughlin et al. (2008).

Improvements to fish marking and monitoring efforts within the Willamette Basin now allow a high level of confidence in distinguishing hatchery-origin from wild (natural-origin) UWR Chinook. Under contract to the USACE, ODFW has since 2002 conducted intensive monitoring of hatchery and wild spring Chinook returning to Foster Dam and to mainstem spawning areas downstream in the lower South Santiam (Schroeder et al. 2006; McLaughlin et al. 2008). Monitoring results from 2002 through 2005 showed that returns of natural origin adults to the South Santiam River were much lower than those of hatchery fish, that hatchery fish dominated the trap catch at Foster Dam and in the spawning areas downstream, and that fewer wild Chinook were spawning successfully in the lower river (<300 fish per year) than returned to the Foster Trap (234-1457 fish per year). Hatchery fish accounted for 79-91% of the spawners in the river from Foster Dam down to Waterloo during this period, and annual pre-spawning mortality rates ranged from 26-72% (McLaughlin et al. 2008). This situation, extended over the long term, would make it improbable that the run of fish could include many natural origin individuals more than a few generations removed from the hatchery. Both natural and hatchery-origin Chinook that enter the Foster Trap are used as hatchery broodstock or are released to spawn in streams above and below Foster Dam, in the Molalla River system, or in the Calapooia River (Beidler and Knapp 2005).

Recent UWR Chinook use of spawning areas within the lower South Santiam subbasin has been intense in the river immediately below Foster Dam and considerably more sparse elsewhere (Figure 4.5-3). Use of all spawning areas that have been monitored within the subbasin has been dominated by the presence of hatchery-origin spawners to the detriment of wild fish (Schroeder et al. 2006).

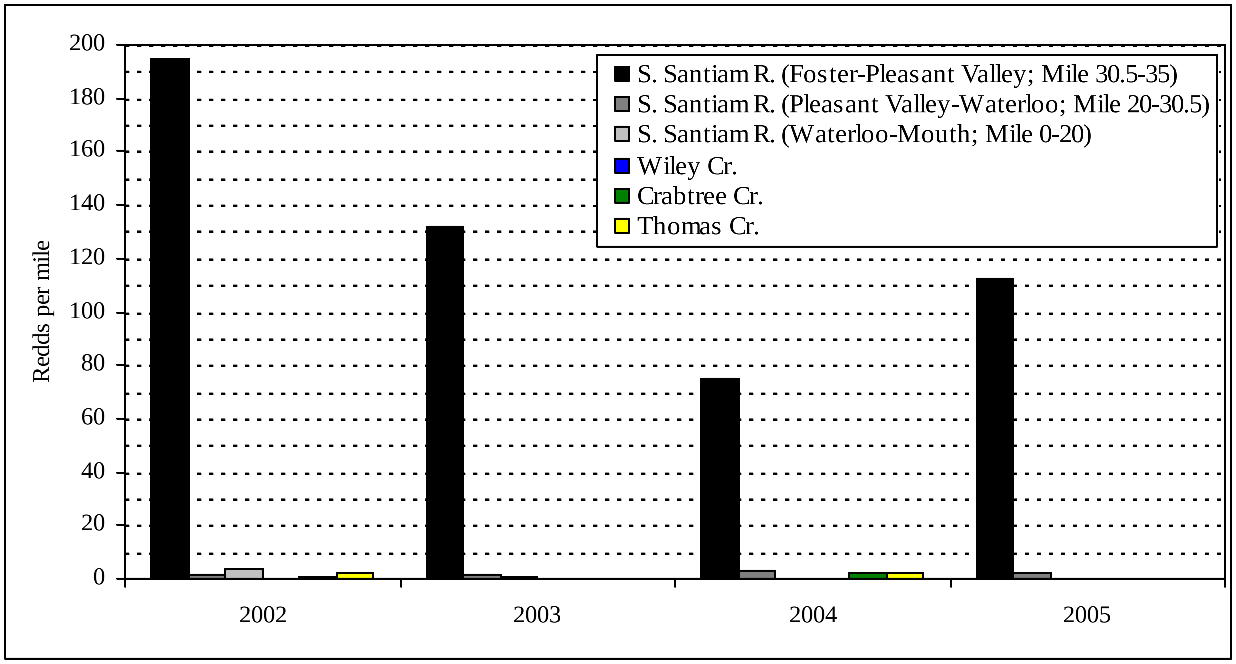


Figure 4.5-3 Spring Chinook redds (nests) per mile surveyed along the South Santiam River immediately below Foster Dam and in other spawning areas examined within the lower South Santiam subbasin, 2002-2005 (Schroeder et al. 2005; StreamNet trends 53769, 56766, 57171, 57173).

Spatial Structure

Reduced spatial structure caused by a lack of effective fish passage at USACE dams and by diminished habitat quality in areas not blocked by dams leads to a high risk of extinction for the South Santiam population of spring Chinook (McElhany et al. 2007). ODFW (2005b) estimates that 40% of the habitat historically suitable for spring Chinook in the South Santiam subbasin is now inaccessible, and McElhany et al. (2007) note that the inaccessible areas held some of the best habitat for the species. ODFW (2005b) estimates that 70% of the subbasin's spring Chinook population once spawned in areas that are inaccessible now.

Diversity

McElhany et al. (2007) rated the current diversity of the South Santiam population of spring Chinook as contributing to a high risk of extinction, based on evidence of life history traits, small effective population size, hatchery impacts, anthropogenic mortality, and reduced habitat diversity. Their greatest concern was the large proportion of hatchery-origin fish in natural spawning areas.

4.5.2.2 Winter Steelhead

Population Viability

The South Santiam population of UWR Steelhead is at low to moderate risk of extinction with considerable uncertainty, based on an analysis of its abundance, productivity, spatial distribution, and diversity (McElhany et al. 2007). The potential for catastrophic events contributes to this risk. WLCTRT 2003 reported the risk of catastrophic losses was high from landslides (based on geology and precipitation patterns), epidemics (due to hatchery releases), and pollution (related to roadway transportation spills).

Abundance & Productivity

In the draft viability assessment for UWR Steelhead (McElhany et al. 2007), South Santiam winter steelhead were rated as most likely in the low extinction risk category for abundance and productivity, with a high degree of uncertainty. The population is relatively large, with McElhany et al. (2007) estimating a long-term geometric mean of 2,727 wild spawners and a recent geometric mean of 2,302.

Abundance of winter steelhead in the South Santiam subbasin is monitored by counting adult fish at Foster Dam and during annual counts of redds within a sub-sample of the available spawning areas. Figure 4.5-4 gives annual counts of the native late-winter run of these fish returning to upper portions of the subbasin, above Foster Dam, from 1967 to 2007. Numbers have declined considerably from those seen in the earliest years following completion of Foster and Green Peter dams. Annual counts of natural origin late-run fish rose above 1,000 for the first time in more than 25 years in 2002 and 2004, but declined to fewer than 500 fish in more recent years.

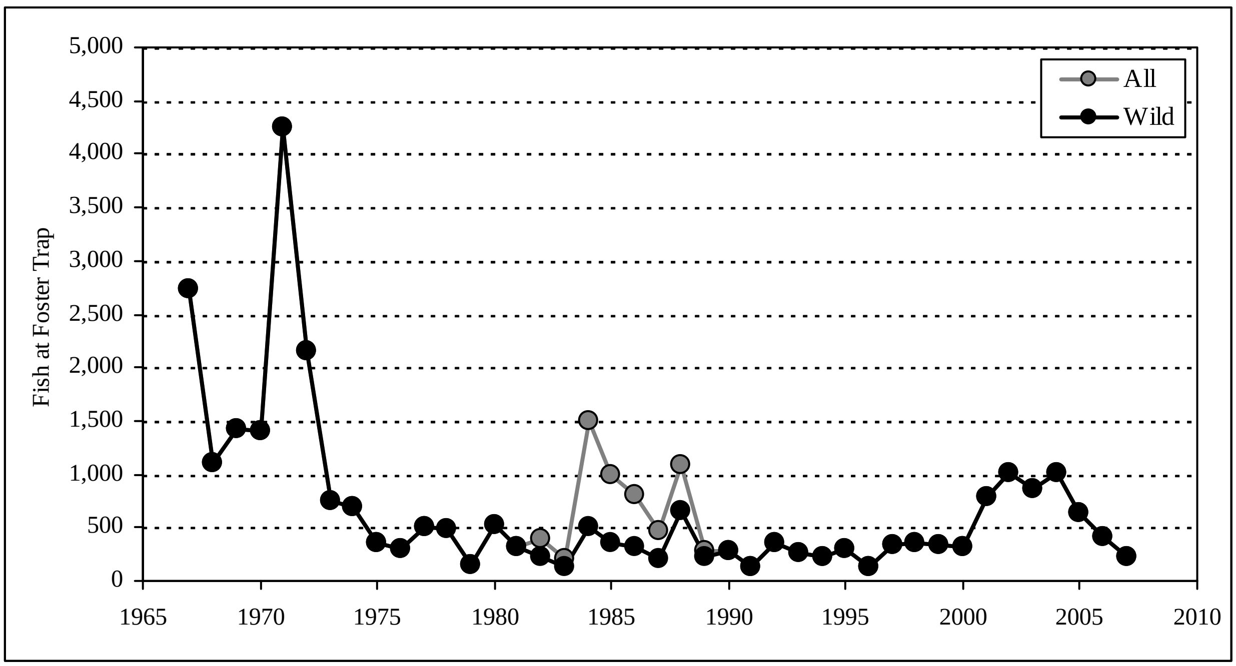


Figure 4.5-4 Returns of native late-run winter steelhead to Foster Dam, 1967-2007 (StreamNet trends 51004, 59182).

Available information suggests that greater numbers of natural origin winter steelhead return to spawn in the lower South Santiam subbasin each year than return to the Foster trap and are released to spawn above Foster Dam. Annual estimates of numbers spawning in the subbasin as a whole averaged 1,953 fish from 2000 to 2006, with an average of 1,236 (63%) of these fish spawning downstream of Foster (Table 4.5-1).

Table 4.5-1 Abundance estimates for native wild South Santiam winter steelhead spawning above and below Foster Dam, 2000-2006. Sources: ODFW (2005b)

YEAR	SPAWNER ABUNDANCE BY RETURN YEAR		
	Above Foster Dam (from dam count)	Below Foster Dam (from ODFW redd counts)	Total
2000	326	687	1,013
2001	783	2,751	3,534
2002	1,002	1,663	2,665
2003	850	873	1,723
2004	1,015	1,531	2,546
2005	626	681	1,307
2006	419	466	885
Average	718	1,236	1,953

Spatial Structure

Winter steelhead spawned historically throughout much of the upper South Santiam subbasin, above the sites of Foster and Green Peter dams, and in Thomas, Crabtree, McDowell, and Wiley creeks, and many smaller streams in the lower subbasin (Willis et al. 1960). However, as described in section 4.5.3.1, ineffective upstream and downstream passage facilities at Foster and Green Peter dams are believed to have caused a drastic reduction in the status of native winter steelhead in the upper subbasin. Early counts of winter steelhead at Green Peter Dam (StreamNet trend 50300), above which they are no longer passed, accounted for as much as 30% of the run above Foster Dam during the first few years after dam completion.

Risks posed to the South Santiam winter steelhead population by reductions in spatial structure appear moderate (McElhany et al. 2007). Fish access to historical habitats above Foster has been impaired by USACE dams, but access to habitat in lower portions of the South Santiam subbasin remains unaffected by these dams (McElhany et al. 2007). ODFW (2005b) estimates that 17% of the habitat historically available to winter steelhead is now blocked at Green Peter Dam. Within lower portions of the subbasin, the distribution of winter steelhead has been affected by low-head passage impediments at non-federal dams, culverts, and diversions in the upper reaches of many low-elevation tributaries and by habitat degradation caused by land and water use practices (McElhany et al. 2007).

Diversity

McElhany et al. (2007) considered available information on the life history traits, small effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity of South Santiam winter steelhead and suggested that the population’s current diversity reflects a moderate extinction risk. Primary risk factors include the legacy of hatchery operations, continued releases of summer steelhead, and reduced habitat diversity.

4.5.2.3 Limiting Factors and Threats to Recovery

Factors adversely affecting the status of the South Santiam populations of UWR Chinook and UWR Steelhead have been summarized by ODFW (2007b). Key limiting factors and threats to both species include a variety of dam effects, large hatchery programs developed partly to help offset dam effects, and the cumulative effects of multiple land and water use practices on aquatic habitat. For the spring Chinook in particular, USACE dams lack effective passage facilities preventing natural origin fish from using historically important habitats in upper portions of the South Santiam subbasin and instead, must rely upon habitats below Foster Dam that have been structurally, hydrologically, and thermally altered. These altered habitats often contain hatchery produced salmonids, or their direct offspring, that compete or interbreed with the wild fish. Habitat changes along the mainstem Willamette River and in the Columbia River estuary, some related to the Willamette Project dams or to other USACE programs, also limit the population.

In all, 14 of 17 primary limitations and 14 of 25 secondary limitations on the recovery of these two ESA-listed populations are related to USACE dams or programs (ODFW 2007b, Table 4.5-2).

Table 4.5-2 Key and secondary limiting factors and threats to recovery of South Santiam Spring Chinook and Winter Steelhead (ODFW 2007b).

		Tributaries (Streams and Rivers within Population Area)									West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
Threats	Species	Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook			4b / 6c					3					4a			
	Steelhead			4c	4d				3						4a		
Hydropower/ Flood Control	Chinook	9e / 7d		10d			1e	2c / 2l				10d		5a,5b,7h,10f / 9j			
	Steelhead	10e / 9e / 7d		10d			1e	2c		2j		10d	10c		5a,5b,7h, 10f / 9j		
Landuse	Chinook			8a	8a / 9a	8a		2g			8a	8a		5a / 6e,8a,9a,9h,9i			
	Steelhead	7a		9a / 10b / 2a		8a						8a			5a / 6e,8a,9a, 9h,9i		
Introduced Species	Chinook				6b												
	Steelhead				6b												

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

1e Mortality at South Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
2c Impaired access to habitat above South Santiam hydropower/flood control dams.
2g Impaired access to habitat above Lebanon dam[1].
3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
4c Competition with naturally produced progeny of hatchery summer steelhead.

[1] This was addressed through FERC-licensed fish passage in 2006

4d Competition with residualized hatchery summer steelhead smolts.
5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
5b Increased microdetrital inputs due to reservoirs.
6b Predation by non-native largemouth bass in Green Peter reservoir.
7h Impaired fine sediment recruitment due to dam blockage.
8a Impaired physical habitat from past and/or present land use practices.
9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
9e Altered water temperatures below the South Santiam hydropower/flood control dams resulting in premature hatching and emergence of Chinook and delayed hatching and emergence of winter steelhead.
10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.
10e Elevated flows during spawning and dewatering of redds below the South Santiam hydropower/flood control dams.
10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
2j Impaired downstream passage at South Santiam hydropower/flood control dams.
2l Prespawning mortality due to crowding below South Santiam hydropower/flood control dams.
4a Competition with hatchery fish of all species.
4b Competition with naturally produced progeny of hatchery spring Chinook.
6c Predation by hatchery summer steelhead smolts.
6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
7a Fine sediment in spawning gravel from past and/or present land use practices.
7d Streambed coarsening below South Santiam hydropower/flood control dams due to reduced peak flows.
8a Impaired physical habitat from past and/or present land use practices.
9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
9e Elevated water temperatures below the South Santiam hydropower/flood control dams resulting in premature hatching and emergence.
9h Toxicity due to agricultural practices.
9i Toxicity due to urban and industrial practices.
9j Elevated water temperatures due to reservoir heating.

10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.

10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

4.5.3 Environmental Conditions

4.5.3.1 Habitat Access

UWR Chinook salmon and UWR steelhead migrations to and from areas above Foster are currently limited by passage conditions at Foster and Green Peter dams and in the reservoirs created by these dams. Prior to construction of the two USACE dams, migrations to and from habitats within the upper South Santiam subbasin had already been influenced by inadequate fish passage on the lower Santiam River at Lebanon Dam (at Mile 21) and in some years by fish weirs constructed at locations on the South and Middle Santiams to collect adult Chinook salmon for hatchery operations. Fish passage measures at Lebanon Dam, a FERC-licensed project that was recently relicensed, were upgraded in 2005 and 2006, with new screens to prevent fish entrainment into the water diversion and fish ladders to minimize delay and injury during upstream fish migration. The temporary hatchery collection weirs had been abandoned by the time the USACE dams were constructed.

Foster & Green Peter Dams as Migration Barriers

Green Peter and Foster dams were both built with fish traps and elevators designed to capture adult salmonids for hatchery broodstock collection and for passage above the dams. Upstream passage for UWR steelhead, but not for UWR Chinook, has been maintained at Foster since dam construction. Passage of anadromous fish was abandoned in the 1980s at Green Peter, when it became clear that wild runs into the Middle Santiam system could not be sustained with existing passage facilities for reasons described below.

Upstream Passage of Adults at Foster

The existing fish trap at the base of Foster Dam is outdated and does not provide adequate upstream fish passage. Fish passing upstream at Foster Dam enter either the tailrace or spillway ladder and then pass up a short section to a trapping area. At the top of the ladder, fish enter a holding pool, where they may be delayed until the next trapping cycle. The holding pool incorporates a combination fish crowder/lifting device to transfer fish to an anesthetic tank. After lifting fish into the tank of water which is infused with dissolved carbon dioxide, and waiting a few minutes for the fish to become hypoxic and easy to handle, hatchery personnel physically climb into the tank and manually remove each incapacitated fish. There are several potential dispositions for fish at this point:

- Lift bucket: Natural-origin steelhead can be placed into the lift bucket, lifted to the top of the dam, and then either 1) lowered and released into the forebay; or 2) placed into trucks waiting at the top of the dam, and transported to release points upstream of Foster Reservoir
- Fish transport tubes: Natural-origin winter steelhead and Chinook salmon and hatchery Chinook salmon and summer steelhead can be placed into one of two fish transport tubes for delivery into

trucks waiting about 200 feet below the dam. One truck takes hatchery fish and some natural-original fish to the hatchery for broodstock, while the other truck transports fish to upstream release sites. and then

- Holding area: Fish can also be returned to the small holding area at the top of the ladder for deferred disposition

Wagner and Ingram (1973) observed numerous sources of injury and mortality of adult salmonids at Foster Dam, primarily associated with fish crowding in the anesthetic tank, handling in the holding pool, and operation of the hopper. It is unclear how many of these problems have been corrected, but concerns include the following:

- The dated design does not include facilities for safe holding, handling, examining, and sorting hatchery- from natural-origin fish (for flexibility in disposition)
- The operator cannot see how many fish are in the trap, creating the potential for crowding and injury during handling
- Inexperienced personnel could injure fish by operating the device improperly
- Use of carbon dioxide as an anesthetic
- Potential injury in the transport tubes (pipe bells are installed downstream, which increase the likelihood of abrasion)

Adult Fallback at Foster

UWR steelhead that are passed above Foster Dam are usually released in the forebay of the reservoir and an estimated 2.5 to 4% of these adults fall back over the dam after release. Studies with marked (floy-tagged) wild adult winter steelhead in 1983 through 1987 indicated a fallback rate (i.e., the proportion released in the forebay and recaptured at the Foster trap) of less than 4%, with little effect of release site in Foster Reservoir (Buchanan et al. 1993). Wagner and Ingram (1973) estimated a fallback rate for wild winter steelhead of 2.5%. They listed the following possible causes for adult fish returning downstream after release into the forebay: injury due to handling, only partial recovery from the anesthetic, rejection of the forebay water, high flow through the adjacent tainter gates attracting fish downstream before they became oriented to the Foster forebay environment, and putting fish into the forebay that were not destined for areas above that dam. The authors thought that some regulation of the spillway tainter gates could reduce the number of fish returning to the tailrace and, in 1971, requested that the USACE avoid spilling from gate 4 (located adjacent to the hopper release site) during periods of upstream migration. On May 5, 1971, Wagner and Ingram (1973) released 100 tagged steelhead into Foster forebay (spill greater than 2,500 cfs until May 15). One tagged adult (1% of the release) was recaptured in the Foster ladder, indicating that this could be a valid operational method of reducing the fallback rate. Buchanan et al. (1993) showed that, for returning hatchery-origin adults, fallback rate was affected by smolt release site. None of the 101 adult hatchery steelhead that were released as smolts high in the watershed, in Moose Creek or Green Peter Reservoir, in 1984 recycled after their release above Foster Dam.

Recent Efforts to Reestablish Adult Chinook Passage at Foster

Since 1996, ODFW has transported and released some of the adult spring Chinook captured in the Foster trap each year into the South Santiam River above Foster Reservoir, in an effort to reestablish a natural run of these fish above the dam. The number released increased from 120 fish in 1996 to 1,850 in 2004. Although juvenile production has been documented from this effort, adult pre-spawning mortality has been high in most years (Beidler and Knapp 2005).

Downstream Passage of Juvenile Fish at Foster

At the time of construction, the Kaplan turbines and subsurface spill gates at Foster Dam were expected to function as downstream fish passage routes; however, studies and observations indicate that downstream fish passage at Foster is less efficient and safe than originally anticipated. Wagner and Ingram (1973) estimated 89.9% survival for juvenile Chinook through the Kaplan turbines during fall, winter, and spring, with slightly higher survival at full pool (91.7% to 92.6%) than at minimum conservation pool (86.6% to 88.9%). Survival rates for juvenile steelhead were similar. Kelts recovered in the downstream nets frequently carried injuries indicating that they had likely been cut by the turbine blades (41% mortality in 1970 tests). The ODFW reported that kelt mortality at Foster Dam was ongoing problem (Krasnow 2001).

Although the turbine intakes were intended to pass juvenile fish, the fish hesitated to sound or dive to the depth of the intakes. Depending on reservoir level, migrating fish must dive about 23 to 49 feet (7 to 15 m) to reach the penstock entrance and 16 to 43 feet (5 to 13 m) to reach the spill gate (USACE 1995). In 1983, ODFW and USACE began a surface spill program to flush juvenile steelhead from the reservoir during the peak migration period. From April 15 until at least mid-May, the reservoir is brought down to elevation 614 feet NGVD (National Geodetic Vertical Datum) and a surface spill of about 300 cfs is provided (USACE 2000). Buchanan et al (1993) reported that smolts passing over the spillway did not appear to suffer injuries and that gas supersaturation was not considered a problem with this operation. This program provides a route for juvenile steelhead that does not require them to dive deep enough to find the penstock entrances or even the depth of the spill gate outlets. Nonetheless, anglers continue to report observations of steelhead “chopped in half” during late winter and early spring (Krasnow 2001). Mortality may be exacerbated if spill is limited in low flow years.

Downstream migrants could also enter the hatchery’s unscreened water supply inlet or the unscreened water supply line for the trap. The mortality associated with each of these routes has not been assessed.

Upstream Passage of Adults at Green Peter

The fish trap at the base of Green Peter Dam is similar to that at Foster but was mothballed in 1988 because the water in the ladder was too cold to attract adults.[2] The ODFW has not released adult Chinook salmon or steelhead above Green Peter in recent years.

Adult Fallback at Green Peter Dam

Adult spring Chinook and winter steelhead released in the forebay of Green Peter Dam sometimes fell back down to the tailrace via the turbines and possibly through the spillway

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[2] Several radio-tagged adults reached the Green Peter tailrace without delay and then remained near the outlet of the smolt bypass and only occasionally approached the entrance to the adult fishway (Buchanan et al. 1993). Relatively warm surface water emerged from the smolt bypass outlet while water in the adult fishway, drawn from the bottom of Green Peter Reservoir, is colder.

(Buchanan et al. 1993). Adult salmon and steelhead were probably killed when they fell back through the penstock entrance and passed through the turbines; those that survived had to move upstream through the fish passage facility a second time, increasing the likelihood of injury.

Downstream Passage of Juvenile Fish at Green Peter

Green Peter Dam was designed with downstream juvenile collection facilities. Downstream migrating juvenile fish were collected at the dam with a juvenile surface collector (this device could move up and down according to varying pool elevations) located well above[3] the turbine intakes, then passed down the face of dam in a pipe (open-channel, shallow flow conditions, initially) then through an evaluator, and then finally released into the tailrace. However, ODFW discontinued releasing both Chinook salmon and steelhead above Green Peter Dam in the late 1980s because survival rates through the reservoir was low (Buchanan 1993) hypothesized to be due to predation.

Tests conducted during the 1980s indicated that the proportion of marked steelhead smolts released above Green Peter Dam and recaptured at the evaluator declined with distance from the forebay and over time (Buchanan et al. 1993). Only a small number of juvenile outmigrants appeared to reach the dam. USACE (1995) hypothesized that the observed decline in collection efficiency from approximately 35% for smolts released into the forebay to 1 or 2% for smolts released into the Middle Santiam River above the head of the reservoir, was related to the slow water velocity and long, convoluted shoreline of the reservoir. USACE (1995) also suggested that the decline in collection efficiency for winter steelhead that Buchanan et al. (1993) observed over time (from less than 90% in the early 1980s to less than 50% by 1988) may have been related to predation by populations of native northern pikeminnow and introduced large-mouth bass. Neither of these hypotheses was evaluated, however. Spring Chinook experienced a similar drop in the percentage of fish collected, from 22% in 1966 to less than 1% in 1985 (USACE 1995). Finally, experiments by Buchanan et al. (1993) showed high rates of injury and mortality for steelhead captured in the evaluator (cloudy eyes, bruises, split tails, and descaling), at least some of which was probably due to the experience in the bypass.

Downstream Passage through the Reservoirs

Predation of juvenile salmon and steelhead by warmwater fish species as well as hatchery rainbow trout has not been directly studied at Foster and Green Peter reservoirs, although, as described above, USACE (1995) hypothesized that it might be a factor in low juvenile fish collection efficiencies at Green Peter. Both reservoirs support a variety of non-native warmwater fish species in addition to native nongame fish including northern pikeminnow (USACE 1982). Green Peter Reservoir supports an introduced population of large mouth bass.

Juvenile fish may be delayed or fail to migrate (termed, “residualize”) from the reservoirs as a result of slow water velocities. As noted above, because of its length, Green Peter reservoir’s low currents could be partly responsible for low collection efficiencies at the juvenile bypass (USACE 1995).

[3] 112 feet above the turbine inlet when the pool was at 922 MSL.

Passage in the Lower South Santiam River and Tributaries

A number of irrigation diversions create migration impediments or barriers along some of the tributaries to the lower South Santiam, including on Crabtree, and Thomas creeks. Some of these diversions have long affected fish passage conditions in these tributaries, particularly for spring Chinook salmon which pass upstream during periods of relatively lower flows (Willis et al. 1960), and add to the constraints that Foster and Green Peter dams place on the distributions of anadromous fish within the South Santiam subbasin.

Summary: Safe Passage & Access to Historical Habitat in the South Santiam Subbasin

Foster and Green Peter dams have delayed adult migrants and have killed and injured juvenile and adult UWR Chinook salmon and UWR steelhead, reducing the abundance and productivity of their populations in the South Santiam subbasin due to ineffective passage. The effect of inadequate passage facilities at Foster Dam continues to limit spatial distribution into much of the historical habitat above this dam. Lack of upstream and downstream passage at Green Peter Dam prevents access to much of the historical Chinook salmon spawning habitat and about 17% of historical steelhead habitat.

4.5.3.2 Water Quantity/Hydrograph

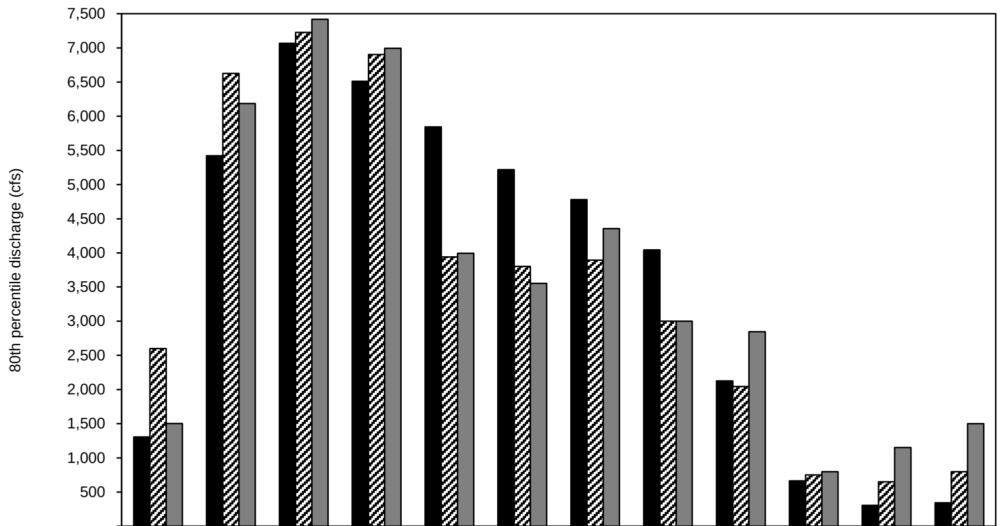
Human-caused alterations of the hydrologic regimes of the South Santiam River and its principal tributaries have generally diminished flow-related habitat quantity and quality and have probably reduced the numbers, productivity, and life history diversity (adult run timing and juvenile outmigrant strategies) of UWR Chinook salmon and UWR steelhead, limiting the production potential of accessible habitat in much of the subbasin. Many of these alterations are attributable to the presence and operation of Green Peter and Foster dams.

4.5.3.2.1 Seasonal discharge pattern

USACE operations intended to control floods and improve water quality have reduced spring flows and increased summer and early fall flows in the lower South Santiam River, below Foster Dam. The increases during summer and early fall offset flow reductions caused by water diversion from the lower mainstem and its tributaries for irrigation, hydropower, and other purposes.

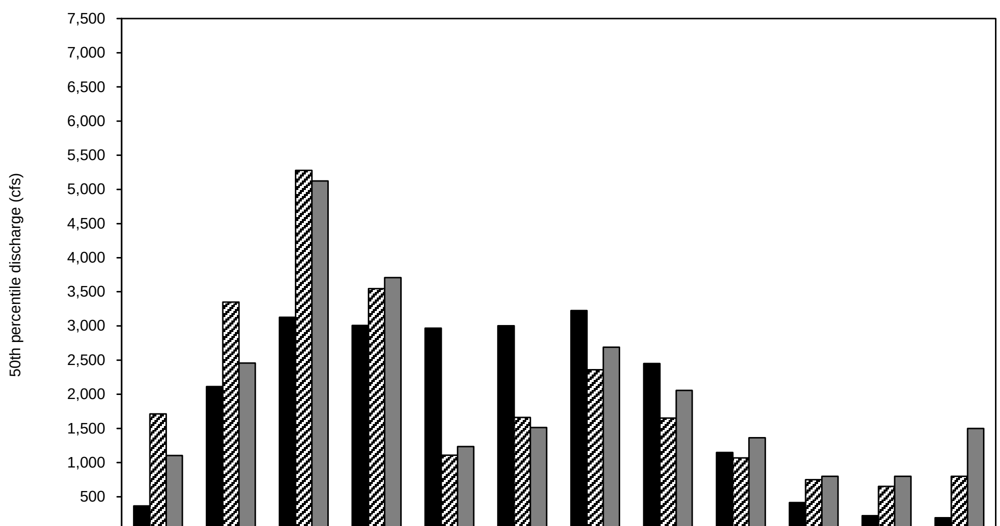
Low flows occur naturally in the South Santiam River and its tributaries but their severity, timing, and frequency have been affected by Green Peter and Foster project operations and an array of downstream and tributary water developments. Green Peter and Foster refill operations have reduced flows in the lower South Santiam River during late winter and spring months (Figures 4.5-5 A, B & C). Operation of Green Peter and Foster dams has reduced median daily April flows below Foster by 17%. In some systems, recruitment of age-0 rainbow trout (*O. mykiss*) has been found to be correlated with late winter flows (Mitro et al. 2003). Thus, spring flow reduction may also reduce the survival of steelhead juveniles. The USACE releases higher than natural flows in September and October to provide space for flood control and to meet mainstem Willamette flow targets, and then drops flow releases in November and December to lower minimums. This release pattern allows UWR Chinook salmon to spawn in elevated areas below Foster Dam during high flows, and these redds may be dewatered prior to emergence, during lower winter flows. Depending on the duration and rate of desiccation, these operations can kill incubating eggs and alevins (Reiser and White 1983). This effect is most severe near Foster Dam and diminishes downstream as unregulated tributaries enter the river.

Figures 4.5-5 A, B & C. Simulated discharge (cfs) of South Santiam River below Foster Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



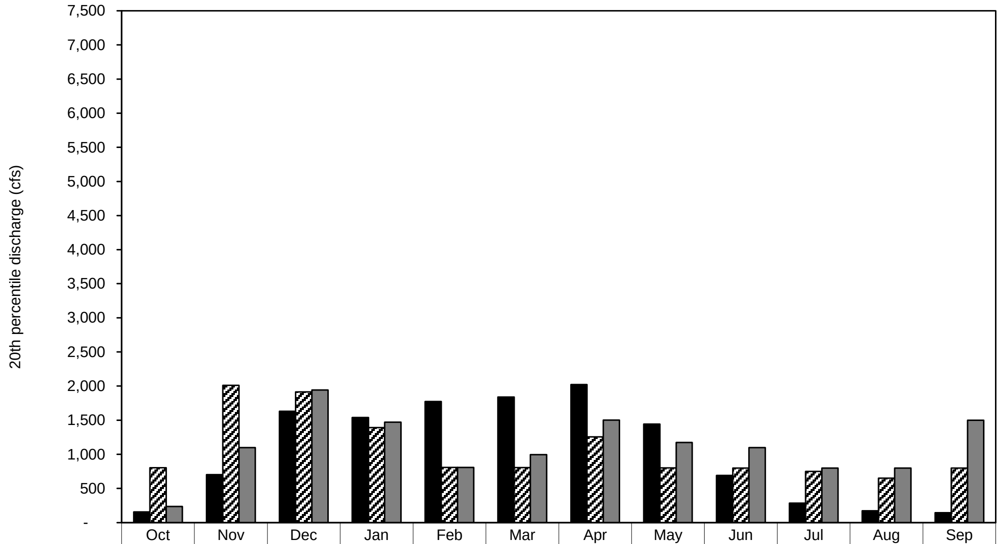
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	1,307	5,422	7,067	6,510	5,844	5,216	4,779	4,044	2,128	664	306	345
Pre-2000	2,601	6,625	7,225	6,904	3,940	3,803	3,893	3,000	2,045	750	650	800
Post-2000	1,503	6,184	7,419	6,996	3,993	3,556	4,357	3,000	2,844	800	1,150	1,500

Figure 4.5-5 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	366	2,113	3,129	3,010	2,970	3,003	3,226	2,450	1,148	413	224	193
Pre-2000	1,712	3,350	5,279	3,547	1,109	1,661	2,358	1,651	1,068	750	650	800
Post-2000	1,103	2,459	5,124	3,707	1,235	1,513	2,689	2,057	1,363	800	800	1,500

Figure 4.5-5 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	155	703	1,632	1,541	1,774	1,839	2,023	1,444	692	285	173	146
Pre-2000	803	2,011	1,915	1,394	809	807	1,256	801	800	750	650	800
Post-2000	236	1,100	1,943	1,472	809	996	1,504	1,175	1,100	800	800	1,500

Figure 4.5-5 C

Flow reductions associated with diversions for irrigation, domestic, and industrial water uses contribute to low flow conditions in the mainstem South Santiam River below Foster Dam and its tributaries, particularly in late summer and early fall (E&S 2000). The South Santiam River supplies water for agricultural, municipal, and industrial water uses. The largest diversion on the mainstem South Santiam is the Lebanon-Albany Canal, located downstream of the Waterloo gage (USGS no. 14187500). The canal can continuously divert between 25 and 200 cfs from the South Santiam River at Lebanon, although diversions never exceeded 156 cfs between 1991 and 1998 (E&S 2000). Most of the diverted water is used by the City of Albany for hydroelectric power, and return flows are released into the Calapooia River, just above its confluence with the mainstem Willamette River. The canal entrance was screened in 2006 as part of the city's FERC license for the project.

The OWRD water availability process (OAR 690-400-011) has determined that natural flow is not available for out-of-stream use from the South Santiam River during the months of August and September. Further, the Willamette Basin Program Classifications (OAR 690-502-0110) require that new surface water users in the subbasin obtain water service contracts from Reclamation (i.e., for the use of water stored in Willamette Project reservoirs during the summer months, including irrigation). In the South Santiam subbasin, those water service contracts are served primarily by water stored in Green Peter Reservoir. Reclamation has contracted a total of 1,096 acre-feet of water from the USACE reservoirs for irrigation within the South Santiam subbasin. Green Peter and Foster reservoirs, as well as Big Cliff and Detroit reservoirs, can also be used to serve contracts for points of diversion of 1,485 acre-feet on the mainstem Santiam River (USACE 2007a).

Water development has also depleted flows in several tributaries to the South Santiam downstream of Foster. E&S (2000) rated the potential for channel dewatering along portions of Neal, Thomas, Ames, and Crabtree creeks as high, and that along Hamilton and McDowell creeks as moderate. These flow reductions generally result from water diversions for irrigation, domestic, and industrial water uses, (E&S 2000), and reduce the habitat available to rearing juvenile spring Chinook salmon and winter steelhead, and in some cases, reduce the available Chinook spawning habitat. In the lower mainstem South Santiam, the effects of water withdrawals are partially offset during July and August when water is released from Green Peter and Foster reservoirs to help meet minimum flow targets at Albany and Salem (see Table 2-10 in Section 2, Proposed Action). The effects of September water withdrawals from the lower South Santiam are reduced by USACE flow releases during the annual fall reservoir draw-down. When the western Oregon rainy season begins in October, natural flows rise and water withdrawals for irrigation are substantially reduced.

4.5.3.2.2 Peak flow reduction

The magnitude and frequency of peak flows in the South Santiam River downstream from Foster Dam have been reduced by flood control operations at Green Peter and Foster dams. Over time, such flood control reduces recruitment and movement of channel substrates and large woody debris, diminishing channel complexity. Side channels, backwaters, and instream woody debris accumulations that would otherwise be created or maintained by floods have been shown to be important habitat features of rearing habitat for juvenile salmonids.

Flows in the lower South Santiam River have been controlled by Green Peter and Foster dams since 1966. Prior to dam construction, the highest instantaneous flow recorded at the Waterloo gage, 14 miles downstream from Foster Dam, was 95,200 cfs and flows greater than 50,000 cfs were common (Hubbard et al. 1997). The maximum flow observed at this site since completion of the projects has been 29,300 cfs. The magnitude of the two-year recurrence flood has decreased in volume from 37,900 to 15,800 cfs. Two major unregulated tributaries, Crabtree and Thomas creeks, enter the South Santiam downstream of Foster Dam and the Waterloo gage, and contribute some flood flows (though to a much less extent than occurred prior to Project dam construction) to the mainstem just upstream of its confluence with the North Santiam River.

Controlling peak flows prevents the flushing of fine sediments that accumulate on the river bed. Interstitial sediments finer than 1 mm can decrease the flow through spawning gravels, reducing the supply of oxygenated water to incubating eggs (Kondolf and Wilcock 1996). Somewhat coarser sediments (1 to 9 mm diameter) can fill interstices and physically block emergence of fry from the bed. Aquatic invertebrates also use open interstices in cobbles and gravel, and fine sediment can eliminate this habitat. The potential reduction in interstitial spaces may also affect juvenile salmonids which are known to use these niches for cover during winter periods (Bjornn and Reiser 1991). These effects are likely to be strongest below Foster Dam and to diminish in a downstream direction as flows and sediments enter the river from unregulated tributaries.

One possible benefit of reduced peak flows is that redds are less likely to be damaged by scouring. Spring Chinook are more likely to benefit from this effect than steelhead because their eggs are incubating through the winter months when floods are most likely to occur.

4.5.3.2.3 Effects of seasonal flow patterns on spawning success

Enhanced flows in the lower South Santiam River during late summer and early fall allow UWR Chinook to spawn close to the edge of the active channel. These are at risk of de-watering and desiccation when flows are reduced during winter flood control operations (ODFW 2007b).

4.5.3.2.4 Flow fluctuations, entrapment & stranding

The South Santiam River downstream from Foster Dam is subject to rapid water level fluctuations, particularly during active flood control operations when discharge may decrease sharply to prevent downstream flooding. Some juvenile salmonids become entrapped and stranded downstream from Foster Dam when discharge is reduced precipitously during winter flood events. This is most pronounced immediately downstream of Foster Dam and diminishes in a downstream direction as flow fluctuations attenuate and unregulated tributaries enter the river. In the South Santiam River, the reach of stream where severe flow reductions are unmitigated by tributary flows is about ½ mile long. At that point, Wiley Creek, a major tributary, enters along the river's left bank.

Ramping rates below Green Peter Dam are unrestricted and highly variable, causing water levels in Foster Reservoir to change by 5 to 15 feet per day (USFWS 1961; USACE 1989a). The magnitude and frequency of flow fluctuations may have rendered the length of the Middle Santiam River between Green Peter Dam and Foster Reservoir unsuitable for fish habitation (USACE 2000).

Prior to 2006, the maximum allowable downramping rate at Foster Dam was 30% of discharge per half-hour. Upramping rates varied from 500 cfs per hour at initial flows between 500 and 1,000 cfs, to 2,500 cfs per hour when initial flows are higher than 18,000 cfs. Ramping operations at Foster Dam were modified in 2006 to reduce fishery impacts. Currently, USACE attempts to maintain ramping rates of 0.1 ft. per hour at night and 0.2 ft. per hour during daylight hours except during active flood damage reduction operations.

4.5.3.3 Water Quality

The ODEQ has rated water quality in the South Santiam basin as excellent (ODEQ WQISR 1996-2005).

4.5.3.3.1 Water temperature

Green Peter and Foster dams affect seasonal water temperature patterns in the lower South Santiam River and to a lesser extent, temperatures in the mainstem Willamette River (see Section 4.10.3.3.1). Within the South Santiam subbasin, their primary influence has been to lower summer temperatures below Foster as a consequence of discharging colder and greater quantities of water into the lower river.

The USACE operates Green Peter Reservoir for meeting mainstem Willamette minimum flows and to attempt to keep it full for summer recreation and drawn down in the fall to create storage space for fall and winter storms. Water is withdrawn from near the bottom and there is a direct relationship between project operations and thermal effects on downstream waters. Although pre- versus post-construction comparisons are difficult (due to differences in the time series available for the USGS gauging stations), operation of Foster and Green Peter reservoirs appears to have reduced average water temperatures in the South Santiam River by up to as much as 5.4^{o}F (3^{o}C) during late spring and as much as 12.6°F (7°C) during summer (May through July), then to increase temperatures by 1.8 to 5.4°F (1 to 3°C) during most of the rest of the year. Most of the effect is due to Green Peter, the larger of the two reservoirs.[4]

Differences between pre- and post-project water temperatures decrease in magnitude with distance downstream. At the Waterloo gage (South Santiam RM 23), average summer water temperatures are about 9.0 to 10.8°F (5 to 6°C) cooler than pre-dam levels (Figure 6-6 in USACE 2000). Hansen and Crumrine's (1991) simulation indicated that, near the mouth of the South Santiam, pre- versus post-construction temperatures differed by less than 1.8°F (1°C). The ODEQ 2004/2006 Integrated Report database indicates that temperatures in the mainstem South Santiam River have exceeded the maximum temperature for salmon and steelhead spawning (55°F; 13°C) in several reaches between RM 0 and RM 60.4. Exceedances have also occurred for core cold water habitat and (61°F; 16°C), and rearing migration (64°F; 18°C) in the South Santiam up through RM 63.4. The USACE (1988) states that average summer water temperatures in the South Santiam River were high before Green Peter was built, often nearing or exceeding 68°F (20°C) (Figures 6-5 and 6-6 in USACE 2000).[5] The USACE (1995) speculated that cooler discharges from Green Peter during early spring and summer may prevent the South Santiam from reaching even warmer, more detrimental temperatures in the fall.

A TMDL for the Willamette Basin was approved for temperature in 2006 (ODEQ 2006a). In this TMDL, ODEQ identified target temperatures for releases below Foster/Green Peter dams, based on stream temperatures inputs to the reservoirs and representing natural temperature regimes prior to dam construction (Table 4.5-3).

Table 4.5-3 Monthly median seven-day rolling average temperatures downstream of Foster and Green Peter dams, and established ODEQ monthly target temperatures (ODEQ 2006a, Chapter 4). No data presented for December through March; allocations/targets were not determined necessary for November through March.

	Foster/Green Peter Release Temperatures	ODEQ Target for Foster/ Green Peter Dam Releases
April	7.7	6.1
May	8.9	8.2
June	10.1	12.4
July	11.7	18.4
August	11.9	18.0
September	12.2	15.5
October	12.2	12.6
November	10.4	12.6

[4] Green Peter Reservoir is 10 miles (16.1 km) long with a useable storage volume of 312 kaf. Foster Reservoir is 3.5 miles (5.6 km) long with useable volume of only 28 kaf. (Sources: USACE 2006; USACE 1989a)

[5] Compared to the North Santiam, the headwaters of the South Santiam are lower in elevation and the snowpack is usually smaller.

As illustrated in Table 4.5-3, the Foster/Green Peter dam complex modified natural temperature patterns in downstream reaches. These modifications include colder summer (June-September) water temperatures.

Water Temperature Control and Site-Specific TMDL Requirements

Operating projects to optimize temperature conditions downstream for fish is often inconsistent with TMDL temperature targets, even with a temperature control tower such as the one constructed at Cougar Dam. Experience in implementing water temperature control operations in the Sound Fork McKenzie River downstream of Cougar Dam to achieve more normative water temperatures suggest that special site-specific considerations may be required for such actions with respect to achieving ODEQ TMDLs. An operational requirement for successfully avoiding high temperature discharges in the fall(i.e., during spring Chinook salmon incubation) is to evacuate as much warm surface water as possible from the reservoir throughout the summer months while operating within the range of appropriate downstream temperature criteria for each month identified by ODFW. That is, it is necessary to balance the effect of warm water temperatures downstream of the dam across the spring, summer and fall periods to achieve the most appropriate overall biological effect. In the South Fork McKenzie River, the requirement resulted in summer water temperatures below Cougar Dam that were will above the draft TMDLs identified by ODEQ during April through September (Figure 4.3-6) in order to provide more favorable temperatures during the critical incubation period in the fall. A focus on achieving the cooler TMDL temperature targets during summer would have adversely affected the temperature conditions achievable during the fall spawning and incubation period for spring Chinook because more warm surface water would have been retained in the reservoir over summer.

Summer and fall exceedances of temperature criteria for salmonid uses are not limited to reaches affected by Willamette Project operations. The ODEQ 2004/2006 Integrated Report database indicates exceedances of the maximum temperature for spawning (55°F; 13°C) and for both core cold water habitat (61°F; 16°C) and rearing and migration (64°F; 18°C) in the South Santiam above Foster Reservoir (up to RM 63.4, near the mouth of Elk Creek).6 Exceedances of the non-core rearing and migration maximum have also been recorded in the Middle Santiam River above Green Peter Reservoir (up to RM 37.1, near the mouth of Ethyl Creek); Quartzville Creek (up to RM 26.8); and in Beaver, Crabtree, Neal, Hamilton, McDowell, Thomas, and Wiley creeks, which are tributaries to the South Santiam River below Foster Dam. The South Santiam Watershed Assessment (E&S 2000) stated that temperature exceedance was a widespread problem through the lower drainages of the South Santiam subbasin, and that there was some evidence that stream temperatures may already exceed standards before flowing through the poorly shaded portions of the watershed. For example, Wiley Creek exceeded standards in its headwaters, where stream shading was assumed to be high.

[6] Temperatures that exceed the maximum for non-core rearing and adult and juvenile migration also exceed the maximum for core rearing areas (61°F; 16°C).

4.5.3.3.2 Other Water Quality Constituents

Dissolved Oxygen

The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the South Santiam subbasin are water quality limited due to low levels of dissolved oxygen, but acknowledges there is insufficient data in many reaches in the basin to determine if the ODEQ standard is met. Historically, the lower reach of the South Santiam River, from the mouth of the river to approximately RM 19, was highly polluted with chemical waste from a paper mill and sewage from the city of Lebanon (McIntosh et al. 1995). The USACE noted that this reach experienced an oxygen block during summer months (USACE 1982). Improved paper pulping processes, secondary wastewater treatment, and summer flow augmentation operations at Foster and Green Peter dams (Section 4.5.2.3) have helped correct these water quality problems.

Total Dissolved Gas

Spill from Foster Dam causes exceedances of TDG in the South Santiam below Foster Dam. On January 25, 1971, Monk et al. (1975) measured a TDG level of 129.2% saturation in the tailrace area (0.4 miles below Foster Dam) during a period when spill was approximately 50% of total flow. A year later (March 3, 1972), TDG was 115.8% at a gage 1.2 miles below the dam (81% spill), and 113.3% another 3.5 miles downstream (78% spill). A background level of 102.9% was measured in the South Santiam River above Foster Reservoir (1.2 miles upstream of Cascadia) on March 7, 1972. Buchanan et al. (1993) reported TDG levels less than or equal to 110.6% of saturation below spillway number 4 during 1979 tests. The 129.2% saturation measured in the tailrace could have caused gas bubble trauma in juvenile salmonids rearing in this area (Appendix E in NMFS 2000b); levels above 105% saturation could adversely affect Chinook yolk sac larvae incubating in this reach. The USACE has not assessed the risk at this location, which would depend on hydrostatic pressure at the depth of the redd and the presence of yolk sac fry during supersaturated conditions. Symptoms of gas bubble trauma have not been reported in juvenile or adult anadromous salmonids in the South Santiam subbasin.

Turbidity

Although landslides may occur in the upper reaches of the South Santiam subbasin, there are no reports of turbidity levels adversely affecting the habitat requirements of spring Chinook salmon or winter steelhead. The ODEQ 2004/2006 Integrated Report database does not list any streams in this subbasin as water quality limited for turbidity.

Nutrients

The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the South Santiam subbasin are impaired due to excessive nutrient loadings. Operations at Green Peter and Foster dams that increased summer flows may have reduced nutrient loads in the mainstem South Santiam River.

Toxics

The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the South Santiam subbasin are water quality limited due to toxics.

4.5.3.4 Physical Habitat Characteristics

Unfavorable human influences on the physical characteristics of habitat for UWR Chinook and of UWR Steelhead tend to be more pronounced in lower portions of the South Santiam subbasin, below Foster, than they are above Foster. A key reason for this is the pattern of ownership and a strong focus on aquatic conservation by public land managers on the Willamette National Forest, within upper portions of the subbasin.

Substrate

Substrates within many streams that are, or have been, used by the South Santiam's Chinook salmon and steelhead populations are influenced by the cumulative effects of various land-use activities and, within the lower South Santiam River, by the effects of Foster and Green Peter dams. As noted, unfavorable influences on habitat tend to be more pronounced in lower portions of the subbasin.

All coarse sediment transported from watersheds above Foster Dam (50% of the South Santiam subbasin) is now trapped by Foster and Green Peter reservoirs. This sediment was historically important to the maintenance of a complex channel network of high-quality salmonid habitats in the lower South Santiam River, including good spawning habitat. One consequence of the reduced quantity of coarse sediment delivered to the lower river has apparently been a coarsening of channel substrates downstream of Foster Dam, potentially reducing the availability of spawning habitat for anadromous salmonids and particularly UWR Chinook salmon. Reduced peak flows, also associated with the USACE dams, have increased the potential for fine sediments to intrude and accumulate in the channel bed and reduce the quality of salmonid spawning habitat in the lower river.

Recent surveys by R2 Resource Consultants (2007) documented the amount of spawning habitat available to UWR Chinook in the mainstem South Santiam between Waterloo and Foster as well as that available to these fish in the mainstems of the upper South Santiam River, the Middle Fork of the Santiam River, and Quartzville Creek, if adult passage is provided at the USACE dams. The surveys did not include several once-used streams above Foster and Green Peter, and therefore provide minimum estimates of what is available above the dams, but found that 21,150 m^2 (66%) of 32,190 m^2 of spawning habitat within the areas surveyed was upstream of Foster.

Large Woody Debris

Streams within the old-growth forests that remain in parts of the upper South Santiam subbasin retain large quantities of in-channel wood. However, a combination of natural disturbances, historical splash-damming, timber harvest, road construction, and other activities have diminished the abundance of large wood in a substantial portion of the drainage network above Foster (WNF SHRD 1995; E&S 2000; BLMS and WNF SHRD 2002). The near-term potential for natural recruitment of large woody debris to many wood-deficient reaches on public lands in the upper subbasin is low enough in some areas that active placement is considered an important option (WNF SHRD 1995). Prospects for significant, widespread large wood recruitment into streams on private lands upstream of Foster is relatively limited (E&S 2000).

All large woody debris that is transported from watersheds above Foster Dam now becomes trapped within Foster and Green Peter reservoirs, and is subsequently removed by the USACE.

Such wood is thought to have contributed historically to the maintenance of a complex channel network of high-quality salmonid habitats in the lower South Santiam River by influencing how the river interacted with its banks and floodplain and by providing hydraulic diversity and hiding cover. Large wood also creates pools and stable gravel deposits in streams (Abbe and Montgomery 1996), habitats utilized by holding or rearing salmonids and the invertebrates upon which they feed.

Without wood from the upper subbasin, the lower South Santiam is dependent on wood recruited from its banks, floodplain, or tributary watersheds. Sources along the banks and floodplain have been diminished by land use and are captured less frequently by the river due to flood control. The three largest tributaries to the lower mainstem, Wiley, Thomas, and Crabtree creeks, drain watersheds whose streams themselves have relatively low wood loading (E&S and 2000). Although intensive timber management and agricultural clearing have reduced wood recruitment potential within these three watersheds, interpretations of air photos suggest that they still have moderate to high recruitment potential in many areas (E&S 2000).[7]

Channel Complexity, Off-channel Habitat & Floodplain Connectivity

Reductions in channel-forming flows, decreased inputs of sediment and large wood, revetments, and bank armoring, can impair the formation and maintenance of complex riverine habitats preferred by salmonids (Appendix E, section E.5). Each of these disturbances has influenced channel conditions along the lower South Santiam River but the effects have not been quantified. However, it is apparent that habitat simplification such as has been documented on the Middle Fork Willamette and lower McKenzie rivers has occurred. The South Santiam below Foster Dam was described in 1947, prior to construction of Foster and Green Peter dams, as being very sinuous, divided by large islands in many places, and actively eroding (USACE 2000). Today, the lower South Santiam River is confined primarily to a single main channel, with few active gravel bars. It also has few perennial secondary channels, and many abandoned alcoves, meander bends, and side-channels that are visible on aerial photographs.

The effects of Green Peter and Foster dams on channel processes downstream in the lower South Santiam River are only partly responsible for the channel simplification that has occurred in the lower South Santiam subbasin. Bank stabilization measures and land leveling for development have also reduced channel complexity and associated juvenile salmon rearing habitat. As of 1989, more than 15 miles of channel bank along the lower South Santiam was protected by rip-rap or revetments, so that 35 percent of the channel downstream of Mile 19 has artificial banks (USACE 1989b). USACE projects account for a total of 7.6 miles of this bank armoring, all below Mile 8.3 (USACE 2000). Additional bank stabilization projects completed along the river downstream of Foster have been documented by E&S (2000).

Riparian reserves & disturbance history

Riparian vegetation along streams in the South Santiam subbasin varies in response to natural differences in geology, precipitation, elevation, and fire regimes, and to man-caused factors

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[7] E&S (2000) define large wood recruitment potential in the following manner: “High” potential areas have sparse or dense mature forest, while “moderate” potential include sparse or dense young forests and riparian wetland vegetation, and “low” recruitment areas consist of urban areas or where grass and shrubs dominate the riparian area.

including: timber harvesting, road building, and land use. It is typically least disturbed in upper portions of the subbasin within the Willamette National Forest and most disturbed along lowland channels passing through areas affected by agricultural, rural residential, or municipal development.

Old-growth forests remain along streams in significant federally-managed portions of the upper South Santiam subbasin, particularly within the Middle Santiam and Quartzville Creek drainages. However, timber harvest, near-stream road construction, and fires have removed these forests from much of the public land and from essentially all private forestlands upstream of Foster (WNF SHRD 1996; E&S 2000; BLMS and WNF SHRD 2002). Recently disturbed riparian forests on federal lands within the upper South Santiam subbasin are now being managed to recover high levels of natural function under the President's Forest Plan. Lower levels of riparian recovery are to be expected along streams on private lands.

The lower South Santiam River, below Foster, has a riparian corridor that includes some significant patches of wide and continuous woody vegetation. However, less than 30% of the lower mainstem is bordered by riparian forest more than 30 m wide, and discontinuous vegetation is common along the channel (E&S 2000). Vegetation has been cleared from much of the lower river's historical floodplain for agricultural or other purposes. Revetments constructed by the USACE, other bank protections, and diminished flooding, inhibit the formation of new riparian forest. Three non-native species have invaded riparian areas along the lower river as well as many of its tributaries: scotch broom, Himalayan blackberry, and reed canary grass.

Tributaries to the lower South Santiam have riparian corridors that have typically been disturbed by land use (E&S 2000). For example, Wiley Creek and its tributaries drain predominantly private timberlands managed under short harvest rotations and with the riparian protections required by the Oregon FPA. The Thomas and Crabtree drainages are also dominated by private lands, but have a mix of federal (BLM), state, and predominantly private forestlands along their middle and upper reaches combined with significant lowland reaches strongly affected by agricultural development. E&S (2000) rated the majority of streamside areas within forested areas of the Crabtree and Thomas creek watersheds as having good or fair riparian continuity but the potential for recruiting large wood to these streams is low because nearly all riparian vegetation in these drainages is less than 80 years old, and most is less than 40 years old. Riparian conditions were generally poorer where the lower mainstems of these streams passed through agricultural lowlands.

4.5.4 Hatchery Programs

UWR Chinook Salmon

Hatchery produced spring Chinook have been present in the South Santiam River since egg collection activities began in 1923 near the town of Foster (Mattson 1948, Wallis 1961). In many early years, sporadic and inefficient operation of a fish collection weir probably allowed a large fraction of the salmon run to escape fish culturists and spawn upstream (Wallis 1961), but in others the hatchery may have collected much of the wild run for broodstock. The South Santiam Hatchery began operations in 1966 to mitigate for Foster Dam, which blocked spring Chinook from most of their historical spawning areas.

The current management strategy for the hatchery Chinook program, as described in section 2.10, is to incorporate some wild fish into the broodstock (so that the hatchery broodstock reflects local adaptation) and to control the percentage of hatchery fish spawning in the wild. The current smolt production goal in the South Santiam is 1.02 million juvenile spring Chinook. NMFS' biological opinion on the USACE hatchery program for UWR Chinook salmon expired in September 2003.

Available information suggests that hatchery-origin spring Chinook are numerically dominant in natural spawning areas within the lower South Santiam subbasin, particularly in the mainstem river immediately below Foster Dam (see section 4.5.2.1). This would appear to pose a threat to the productivity of the natural population (ODFW 2007b). Most freshwater coded-wire tag recoveries from South Santiam hatchery spring Chinook salmon have been made within six miles of the hatchery (Myers et al. 2002).

During the past decade, some of the hatchery-origin spring Chinook returning to Foster Trap have been outplanted in an effort to test the ability to reinitiate or rebuild runs of UWR Chinook in historically occupied areas. Some of these adult fish have been released above Foster Reservoir, often accompanied by natural-origin fish that were also collected at the trap (see section 4.5.3.1). Others have been released, also sometimes accompanied by natural-origin adults from the trap, into tributaries to the lower South Santiam River (Table 4.5-4) or outside the subbasin. Pre-spawn mortality of the adults released has generally been high (Beidler and Knapp 2005). Those fish that have spawned appear to have been able to produce juvenile Chinook in the receiving streams, though survival rates from egg deposition to juvenile lifestages is unknown (Beidler and Knapp 2005).

Table 4.5-4 Numbers of adult spring Chinook salmon outplanted in the South Santiam subbasin 1998-2006 (Beidler and Knapp 2005) and (McLaughlin et al. 2008).

YEAR	TRIBUTARIES BELOW FOSTER DAM		
	Thomas Creek	Crabtree Creek	Wiley Creek
1998	107	40	0
1999	101	0	0
2000	289	130	0
2001	565	397	0
2002	461	359	546
2003	155	173	101
2004	237	246	247
2005	193	143	166
2006	180	256	0

Summer Steelhead & UWR Steelhead (winter)

Hatchery-origin winter steelhead returning to the South Santiam River were reared at the former South Santiam Hatchery on Coal Creek from 1926 through 1944. After 1944, the South Santiam stock was infrequently reared in a hatchery (ODFW 1986) and was often supplemented with fish from the Marion Forks Hatchery in the North Santiam subbasin (ODFW 1990a). Hatchery releases of winter steelhead have not occurred in this basin since 1989 (Chilcote 1997).

4.5.5 Fisheries

Until recently, wild spring Chinook salmon were subjected to relatively intense commercial and recreation fisheries in the lower Columbia and Willamette rivers that were directed primarily at the abundant hatchery-origin fish. Freshwater harvest rates for Willamette spring Chinook were on the order of 35-40% prior to ESA listing of UWR Chinook, but have since been reduced to approximately 8-12% since 2001. Fishery objectives in the Willamette River have been changed to emphasize the protection of natural-origin fish.

The State of Oregon developed a Fisheries Management and Evaluation Plan under NMFS' 4(d) Rule for the management of spring Chinook salmon fisheries in the Willamette River. This management plan specifies the harvest regime for spring Chinook salmon and has been approved by NMFS under the ESA. Total mortality in commercial and sport fisheries occurring in freshwater are capped at 15%. However, annual mortality rates since implementation of selective, catch-and-release fisheries for wild spring Chinook have more typically been in the range of 8-12% (ODFW 2008c). Impacts on natural-origin spring Chinook have been significantly reduced while maintaining a relatively high harvest of hatchery-origin adults.

4.5.6 Status of PCEs of Designated Critical Habitat in the South Santiam Subbasin

NMFS determined that the following occupied or unoccupied areas of the South Santiam subbasin contain Critical Habitat for UWR Chinook salmon or UWR steelhead (NMFS 2005d; maps are included in section 303 of this Opinion):

UWR Chinook (spring-run)

- Habitat of high or medium conservation value for these fish, and deemed important to their recovery, is present in all six occupied watersheds within the South Santiam subbasin (NMFS 2005g). In aggregate, these six watersheds contain 79.3 miles of PCEs for spawning/rearing and 89.4 miles of PCEs for rearing/migration (NMFS 2005g). All of the evaluated watersheds have been designated as Critical Habitat (NMFS 2005d), as described below:
    - The South Santiam River and South Santiam River/Foster Reservoir watersheds, both above Foster Dam, have high conservation value and combine to provide 25.4 miles of spawning/rearing habitat and 4.7miles of rearing/migration habitat (NMFS 2005g).
    - The Hamilton Creek/South Santiam River watershed, below Foster Dam, has high conservation value and provides 16.5 miles of spawning/rearing habitat and 40.7 miles of rearing/migration habitat (NMFS 2005g).

- The Wiley Creek, Thomas Creek, and Crabtree Creek watersheds, all below Foster Dam, have moderate conservation value and contain a total of 37.4 miles of spawning/rearing habitat and 44.0 miles of rearing/migration habitat (NMFS 2005g).

➢ Two watersheds that account for all South Santiam tributaries above Green Peter Dam, Middle Santiam River and Quartzville Creek, are unoccupied at present but did support the species prior to dam construction. They have not been fully evaluated as potential critical habitat, but contain as much as 38.3 miles of habitat once used by UWR Chinook and may be important to species conservation (NMFS 2005g).

UWR steelhead

➢ Habitat of high conservation value, and important to the recovery of these fish, is present in all six occupied watersheds within the South Santiam subbasin (NMFS 2005g). In aggregate, these six watersheds contain 152.1 miles of PCEs for spawning/rearing, 72.2 miles of PCEs for rearing/migration, and 5.4 miles of migration/presence habitat (NMFS 2005g). All of the occupied watersheds have been designated as Critical Habitat (NMFS 2005d), as described below:

- The South Santiam River and South Santiam River/Foster Reservoir watersheds are above Foster Dam and combine to provide 44.6 miles of spawning/rearing habitat and 8.3 miles of rearing/migration habitat (NMFS 2005g).
- The Hamilton Creek/South Santiam River, Wiley Creek, Thomas Creek, and Crabtree Creek watersheds are all below Foster Dam and contain a total of 107.5 miles of spawning/rearing habitat, 63.9 miles of rearing/ migration habitat, and 5.4 miles of migration/presence habitat (NMFS 2005g).

➢ Two watersheds that account for all South Santiam tributaries above Green Peter Dam, Middle Santiam River and Quartzville Creek, are unoccupied at present but did support UWR steelhead prior to dam construction. The watersheds have not been fully evaluated as potential critical habitat, but contain as much as 48.4 miles of habitat once used by UWR steelhead and may be important to species conservation (NMFS 2005g).

Bank protection measures associated with USACE activities total 95,164 linear feet (18.02 miles) between RM 0.9 and RM 29.1 in the South Santiam, with 40,620 feet (7.69 miles) on the right bank, and 54,544 feet (10.33 miles) on the left bank, In the Santiam River below the confluence of the South Fork between RM 0.8 and RM 8.3, there are an additional 40,258 linear feet (7.62 miles) of bank protection measures, with 24,599 feet (4.66 miles) on the right bank and 15,659 (2.97 miles)on the left bank (USACE 2000). These measures affect spawning/rearing and rearing/migration habitats, designated as critical habitat, in the South Santiam and lower Santiam rivers (NMFS 2005d).

NMFS (2005g) identified the key management activities that affect these PCEs. Key management activities affecting the upper watersheds include dams and forestry management. Key activities affecting the mid and lower watershed include agriculture, channel modifications/diking, irrigation impoundments and water withdrawals, road building and maintenance, and urbanization, in addition to dam and forestry activities.

As discussed in previous sections, Foster and Green Peter dams blocked or reduced access to upstream spawning and rearing habitats, reduced downstream migrant survival, altered flows downstream, reduced or eliminated marine-derived nutrients from upper watersheds, and limited the downstream transport of habitat building blocks. Green Peter Dam altered the habitat above the dam by creating a 10 mile-long reservoir from about RM 5.7 to RM 15.7 inundating 10 miles of riverine habitat. Foster Dam also inundates riverine habitats within critical habitat above the dam by creating a 3.5 mile-long reservoir. Foster and Green Peter dam operations also negatively altered downstream water temperatures.

Table 4.5-5 summarizes the condition of PCEs within the South Santiam River. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most cases, this is the result of the past operation and the continuing effects of the existence of the Projects or the effects of other human activities (e.g., development, agriculture, and logging). However, to the extent these conditions would be perpetuated by future operations or existence of the project, only the past impacts and project existence are included in the baseline.

Table 4.5-5 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the South Santiam subbasin under the environmental baseline.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Operation of USACE reservoirs reduced spring/summer temperatures in the South Santiam River and increased temperatures during most of the rest of the year The ODEQ 2004/2006 Integrated Report database indicates that temperatures in the mainstem South Santiam River have exceeded the maximum temperature for salmon and steelhead spawning (55°F; 13°C) in several reaches between RM 0 and RM 60.4. Exceedences have also occurred for core cold water habitat and (61°F; 16°C), and rearing migration (64°F; 18°C) in the South Santiam up through RM 63.4. Summer water temperatures in the South Santiam River often neared or exceeded 68°F before Green Peter; cooler spring/summer discharges from Green Peter may prevent the lower South Santiam from reaching warmer temperatures in the fall ODEQ 2002 CWA 303(d) database indicates exceedences of the maximum for spawning (13°C), core cold water habitats (16°C), and rearing and migration (18°C) in the South Santiam above Foster Reservoir; exceedences of the maximum for rearing and migration maximum have also been recorded in the Middle Santiam River above Green Peter Reservoir; and for core coldwater habitat, and rearing and migration in Quartzville Creek. Temperatures below Foster Dam (1968-1972) were less than 52°F during May through early July – cold enough to delay upstream migration of spring Chinook	USACE operations (Green Peter) Agriculture Water withdrawals USACE operations (Foster and Green Peter) Revetments Natural conditions Benefit of USACE operations Timber harvest USACE operations (especially Green Peter)

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/Turbidity	No reports of turbidity levels adversely affecting the habitat requirements of spring Chinook salmon or winter steelhead The ODEQ 2004/2006 Integrated Report database does not list any streams in this subbasin as water quality limited for turbidity	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/Nutrients	The ODEQ 2004/2006 Integrated Report database does not indicate that any streams are water quality limited due to the presence of toxics The ODEQ 2004/2006 Integrated Report database does not indicate that streams in the South Santiam subbasin are impaired due to excessive nutrient loadings Operations at Green Peter and Foster dams that increased summer flows may have reduced nutrient loads in the mainstem South Santiam River	N/A N/A Benefit of USACE operations

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Dissolved Oxygen (DO)	Historical pollution due to pulp mill effluent and sewage in the lower 19 miles; oxygen block during summer months Improved paper pulping processes, secondary wastewater treatment, and summer flow augmentation from Foster and Green Peter dams helped correct the problem The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the South Santiam subbasin are water quality limited due to low levels of dissolved oxygen	Pulp mill Municipal sewage Benefit of USACE operations (esp. Green Peter)
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	A TDG level of 129.2% saturation, measured in the tailrace in January 1971, was high enough to cause gas bubble trauma in juvenile salmonids rearing in the area and could kill Chinook yolk sac larvae incubating in this reach TDG levels of 115.8% at 1.2 miles below Foster Dam and 113.3% another 2.3 miles downstream (March 1972) could also have killed yolk sac larvae Symptoms of gas bubble trauma have not been reported in juvenile or adult anadromous salmonids in the South Santiam subbasin	Regulating outlet spill – USACE operations at Foster Dam

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat access	Physical barriers	Barriers below Foster Dam Rebuilt ladders and new screen at Lebanon Dam (RM 21), which diverts water into the Lebanon-Albany power canal for irrigation, hydropower, and municipal use, allows safe passage of juvenile fish downstream and adult fish in both directions past this small dam on the lower S. Santiam River Several older fish ladders in tributaries allow passage of adult spring Chinook salmon but probably cause some migration delay Irrigation diversions on the lower tributaries of Crabtree and Thomas creeks pose migration barriers to adult spring Chinook Barriers above Foster and Green Peter reservoirs Hatchery broodstock collection began near the site of Foster Dam in 1923 and was discontinued in the 1930s A weir was on the Middle Santiam River, a few miles upstream from the confluence with the South Santiam River; fell into disuse in the 1930s	Privately-owned diversions, dams, and hydroelectric facilities State hatchery operations

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat access	Physical barriers	Foster Dam as a barrier to upstream migrants No estimates of upstream passage mortality at Foster Dam Dated design does not allow facilities for holding, handling, examining, and sorting hatchery- from natural-origin fish (flexibility in disposition) The operator is unable to see how many fish have accumulated in the trap, leading to potential crowding and injury during handling The device can be operated improperly by inexperienced personnel, leading to fish injury	USACE operations (Foster)
Freshwater migration corridors	Habitat access	Physical barriers	Foster Dam and Reservoir as a barrier to downstream migrants Kaplan turbines expected to safely pass juveniles but fish hesitate to dive to intakes Surface spill used to flush juvenile steelhead from the reservoir since 1983 89.9% survival for juvenile Chinook through Kaplan turbines (similar rates for juvenile steelhead) 41% mortality of steelhead kelts recovered in the downstream nets Fallback at Foster Dam Estimated fallback rates for wild winter steelhead of 2.5 to 4%	USACE operations (Foster) USACE operations (Foster)

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat access	Physical barriers	Green Peter Dam as a barrier to upstream migrants Adult passage facility at Green Peter mothballed in 1988; water in the ladder was too cold to attract adults Green Peter Dam and Reservoir as a barrier to downstream migrants Slow water velocity and long, convoluted reservoir shoreline Populations of native northern pikeminnow and introduced large-mouth bass High rates of injury and mortality for steelhead captured in bypass evaluator Fallback at Green Peter Dam Adult spring Chinook and winter steelhead released in the forebay of Green Peter Dam sometimes fall back down to the tailrace via turbines (and possibly through the spillway) Surviving fallback had to move upstream through the fish passage facility a second time, increasing the likelihood of injury	USACE operations (Foster) USACE operations (Green Peter) USACE operations (Green Peter)

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat access	Physical barriers	Predation as a barrier to reservoir migration Foster and Green Peter reservoirs support native northern pikeminnow Green Peter supports a population of nonnative large mouth bass	USACE operations (Foster and Green Peter)
Freshwater spawning sites	Habitat elements	Substrate	Substrate has coarsened downstream of Foster Dam. River channel downstream of Foster Dam may be downcutting. Channel downstream of Foster Dam could lack spawning gravel Many areas scoured to bedrock Current sediment budget not creating and maintaining side channel and gravel bar habitat needed by anadromous salmonids	USACE reservoirs trap sediment from headwaters USACE operates Foster/Green Peter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments Gravel mining Historical log drives

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	In Tributaries and upper South Santiam mainstem Large wood is lacking in most small tributaries and the upper South Santiam; very few reaches meet the ODFW benchmarks Future recruitment potential for large wood is low along the lower portions of surveyed streams, but relatively high in upper reaches	Timber harvesting Stream clean-out Unique sequence of fire and flood disturbance in upper South Santiam Fire suppression
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	In the mainstem South Santiam River-- Reaches of the South Santiam River below Green Peter and Foster dams are deprived of large wood Inadequate recruitment of large wood from riparian areas along mainstem South Santiam and tributaries downstream from Foster Dam Lack of large wood-associated habitat for anadromous salmonids and invertebrates upon which they feed	USACE removes large wood from reservoirs USACE removed snags in lower river for navigation Inadequate recruitment from riparian forests USACE and private revetments prevent recruitment from banks. USACE operation of Green Peter and Foster dams reduces frequency of channel-forming flows needed to recruit large wood from banks.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool Frequency and Quality	Pool frequency and quality in the South Santiam River downstream of Green Peter/Foster dam complex is fair.	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity	USACE operates Foster/Green Peter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments
Freshwater spawning sites Freshwater rearing	Channel conditions and dynamics	Width/depth ratio	Channel forming processes in the South Santiam River downstream of the Green Peter/Foster dam complex have been restricted by changes to the natural hydrograph and by reductions in sediment load and LWD derived from areas located above the dams. Flow regulation, fractionation of the sediment load passed to below the dams, and accumulation of fine sediment fractions below Foster Dam have resulted in bank and substrate armoring (i.e., compaction and stabilization) and in habitat simplification.	USACE reservoirs trap sediment from headwaters. USACE operates Foster/Green Peter Dams to reduce magnitude/frequency of peak flows. USACE and private revetments.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Streambanks do not support natural floodplain function in the lower South Santiam River downstream of the Green Peter/Foster dam complex.	USACE operates Foster/Green Peter dams to reduce the magnitude/frequency of peak flows USACE and private revetments
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests Lower South Santiam is confined primarily to a single main channel. While no quantitative data are available, the South Santiam likely contains fewer off-channel habitats, simplified mainstem habitat, and few new gravel bars or side channels.	USACE operates Foster/Green Peter Dams to reduce the magnitude and frequency of peak flows USACE and private revetments USACE removes large wood from reservoirs Gravel mining in lower river USACE traps sediment in Green Peter and Foster reservoirs.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/Hydrology)	Change in peak/base flow	Increased fall flows may allow spring Chinook to spawn in areas that will be dewatered during active flood control operations Winter and spring flow reductions may reduce rearing area and the survival of steelhead fry.	Fall releases from Foster and Green Peter dams to create storage space Winter flood control and late winter and spring refill operations at Foster and Green Peter reservoirs Flow augmentation from Foster and Green Peter dams to meet mainstem targets
			Increased summer flows may increase rearing area and the heat capacity of the stream	Summer diversions at Lebanon-Albany Canal and others, including those served by USBR contracts
			Low summer flows in specific reaches (due to diversions) may reduce the juvenile rearing habitat area, block adult passage to upstream spawning areas, and decrease the heat capacity of the stream	Flood control operations at USACE's Green Peter and Foster dams cause rapid flow reductions Rapid changes in diversion rates at the Lebanon-Albany Canal
			Flow fluctuations now occur at rates rapid enough to entrap and strand juvenile anadromous fish.	Flood control operations at USACE's Green Peter and Foster dams
			Frequency of channel-forming flows not of sufficient magnitude to create and maintain channel complexity and provide nutrient, organic matter, and sediment inputs from floodplain areas	

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Road density and location	Moderate to high road densities exist in South Santiam watershed above and below the Green Peter/Foster dam complex. These roads are managed by Oregon Dept. Transportation and by USFS; corrective measures are not included as a part of the revised proposed action.	
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Disturbance history	Some forests in the upper watershed are dominated by early- to mid-successional stages, but up to 39% of the Middle Santiam and 43% of the Quartzville drainages contain late-successional forests Disturbance regime is dominated by timber harvesting, which can increase sediment delivery to streams, while decreasing large wood input. Upper watershed is predominantly forested. Lower watershed contains extensive agricultural, urban, rural, and residential development.	Fire suppression Timber harvesting Conversion to agricultural, urban, residential, and rural uses Flood control provided by USACE operations at Green Peter and Foster dams has probably increased agricultural, urban, rural, and residential development within the South Santiam floodplain.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Headwater forests riparian conditions Riparian areas in upper watershed tributaries dominated by late-successional vegetation on federal land and early-successional vegetation on private lands Width and continuity of riparian areas are good along Thomas and Crabtree Creeks in the lower South Santiam subbasin, but almost all vegetation is less than 80 years old Riparian areas in many tributaries do not provide adequate shading or large wood recruitment Floodplain forest riparian conditions Low large wood recruitment potential because: Less than 30% of the riparian forest along the mainstem South Santiam river is greater than 30 m wide Many remaining patches of floodplain forest are interspersed with pastureland	Timber harvesting Stream clean-out practices Conversion to agriculture Clearing for agriculture or development USACE and private revetments USACE operation of Foster/Green Peter Dams alters the hydrologic regime Private dikes Timber harvest

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Section 4.6
North Santiam Baseline

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4.6 NORTH SANTIAM SUBBASIN

The North Santiam River is about 92 miles long and drains an area of approximately 763 square miles as it flows from headwaters in the Mount Jefferson Wilderness Area of the Willamette National Forest to its confluence with the South Santiam River near Jefferson, Oregon (Figures 4.6-1 and 4.6-2). Eighty-two percent of the contributing area is forested and 65 % is in public ownership (NRCS 2006c). Major tributaries to the North Santiam include Marion Creek (RM 85.3), the Breitenbush River (RM 65.9), Blowout Creek (RM 64.0), and the Little North Santiam River (RM 39.1). The Little North Santiam is the only major tributary that enters the North Santiam between the USACE's Big Cliff and Detroit Dams (located at RM 58.1 and 60.9, respectively) and the South Santiam River. Below the South Santiam confluence a river segment 11.6 miles long and known as the mainstem Santiam flows to the mainstem Willamette River. The main Santiam is frequently included in discussions of the North Santiam and in measuring river distances (RM) from the mainstem Willamette, and is here.

Above the reservoirs associated with Detroit and Big Cliff dams, the North Santiam drainage is characterized by steep, forested terrain that lies almost entirely within the Willamette National Forest, although there are some private in-holdings. Below the dams, the North Santiam River passes through a steep forested canyon to approximately RM 50, near the town of Gates, where the canyon widens, the channel gradient decreases, and the river begins to meander (USACE 2000). The river valley widens and the channel gradient decreases further (to <0.3%) near Mehama (at RM 37, just downstream of the Little North Fork confluence). The North Santiam channel becomes more sinuous below this point and was once described by the USACE (1947) as "crooked and frequently divided by large islands."

Most of the land along the reach of the North Santiam from Mehama to its confluence with the South Santiam River, as well as the 12-mile mainstem Santiam River, is used to grow agricultural crops or graze livestock. The remainder consists of urban areas, coniferous forests, mixed deciduous forests, and riparian forests that now comprise less than 7% of the vegetation (E&S 2002). Most of the subbasin's residential and rural-residential development is downstream of the USACE dams, on the valley floor and in the foothills.

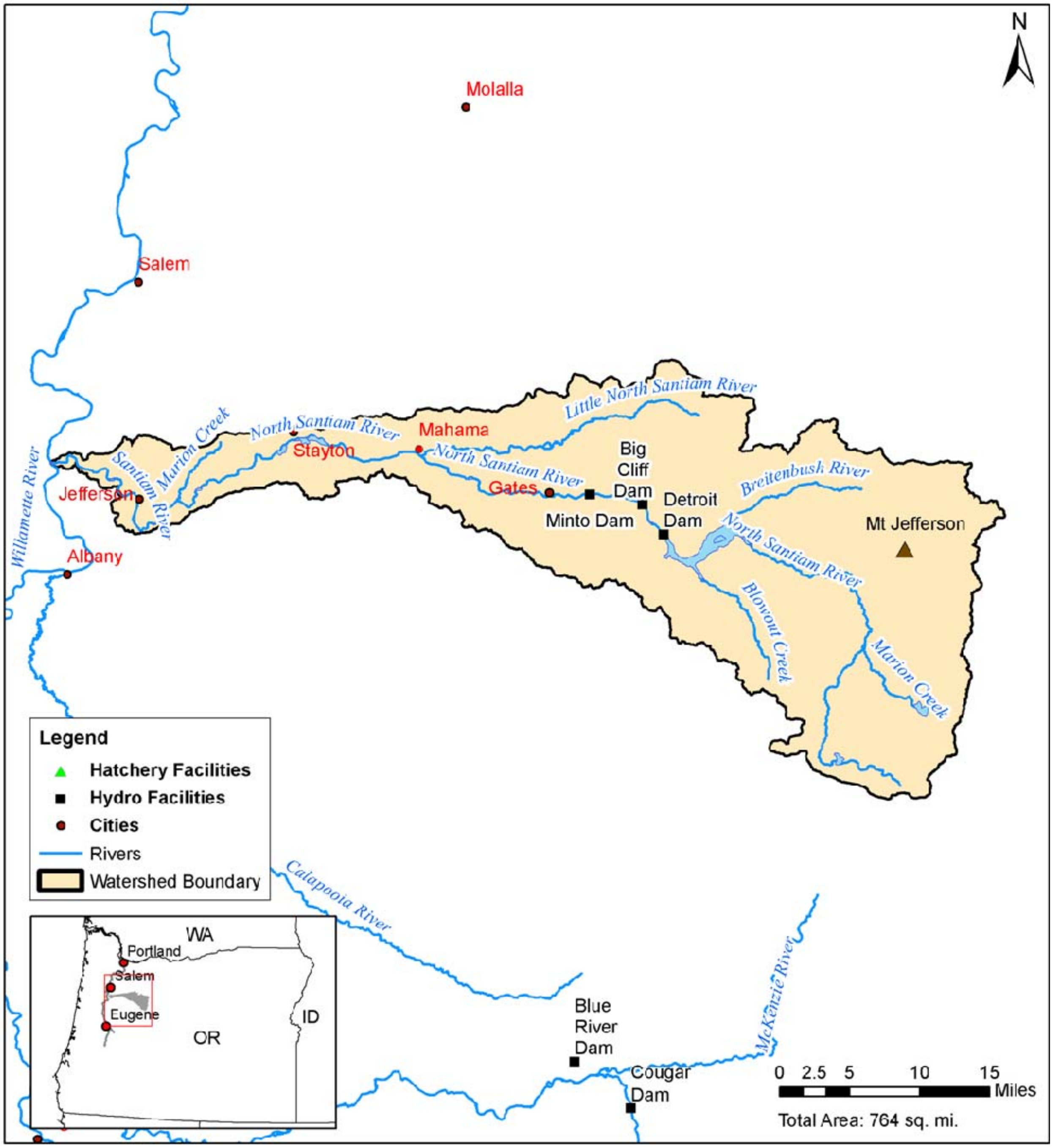
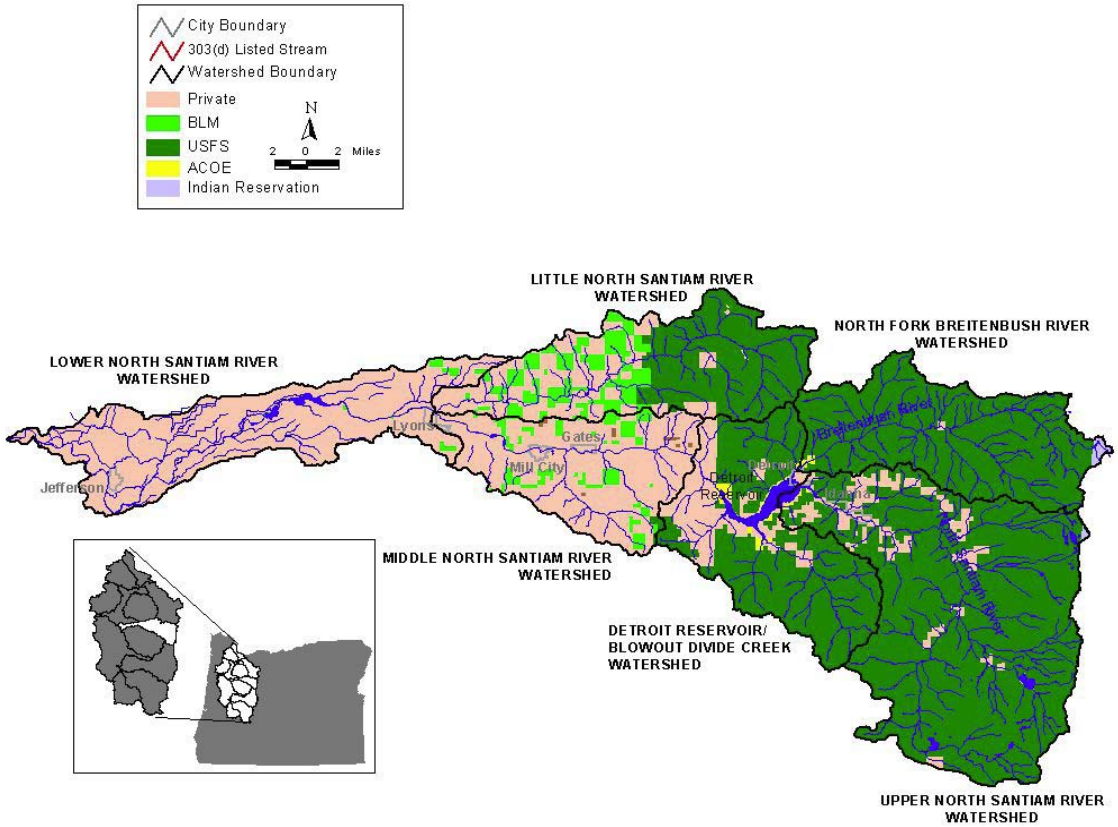
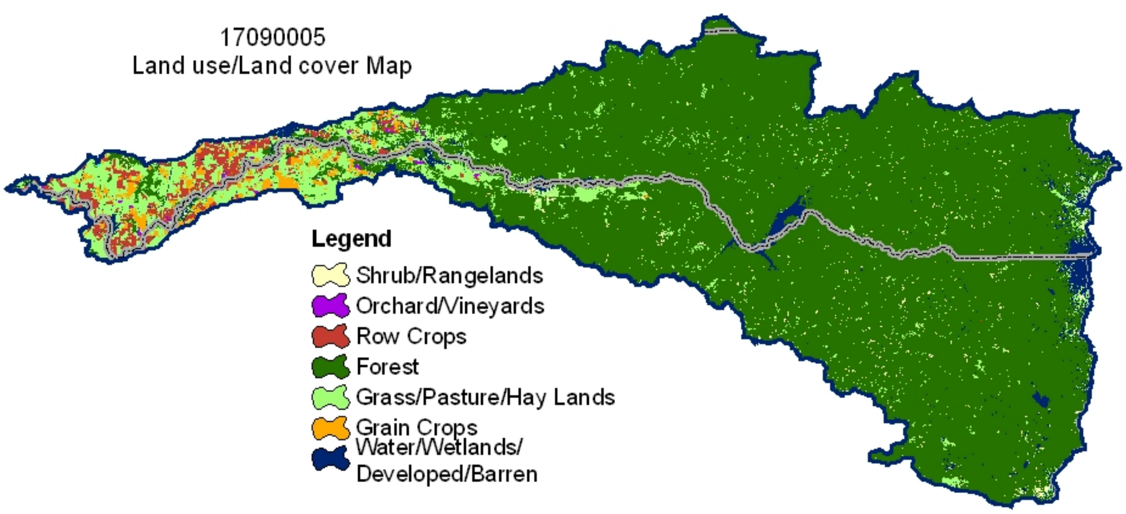


Figure 4.6-1 North Santiam Subbasin





Figures 4.6-2 Maps of the North Santiam subbasin (ODEQ 2003; top) and of land use patterns within the subbasin (NRCS 2006c, bottom).

4.6.1 Historical Populations of Anadromous Salmonids in the Subbasin

The North Santiam subbasin is the natural home of an independent population of UWR Chinook and independent population of UWR steelhead. Historical information on these populations is given below.

UWR Chinook

The mainstem North Santiam River is free of natural barriers up to its headwaters, approximately 35 mainstem miles above Detroit Dam (WNF DRD 1995). Before the USACE dams were constructed, adult Chinook salmon spawned in the upper reaches of the North Santiam River and in headwater tributaries such as the Marion Creek, the Breitenbush River, and Blowout Creek (WNF DRD 1994, 1996, 1997), as well as in the mainstem below the dam sites and in Little North Santiam River (Parkhurst et al. 1950). Historical estimates of the abundance of these fish in the North Santiam subbasin range from 8,250 adults escaping to spawn upstream of Detroit Dam in 1934 (Wallis 1963) despite intense downstream fisheries, to 2,830 spawners throughout the entire subbasin in 1947 (Mattson 1948). Parkhurst et al. (1950) estimated that there was sufficient habitat in the North Santiam to accommodate at least 30,000 adults. Mattson (1948) estimated that 71% of the spring Chinook production in the North Santiam subbasin occurred in areas that have since been blocked by Detroit and Big Cliff Dams.

UWR Steelhead

Surveys conducted in 1940, before the dams were constructed, led to estimates of at least 2,000 steelhead spawning in the mainstem North Santiam, with additional runs to the Breitenbush River, Marion Fork, Pamelia and Blowout creeks, and the Little North Santiam (Parkhurst et al. 1950). The species also used many smaller streams in these and other tributary drainages (BLMS 1998; Olsen et al. 1992; WNF DRD 1994, 1995, 1996, 1997). After construction of the dams, Thompson et al. (1966) estimated that the entire North Santiam subbasin supported a population of 3,500 winter steelhead, including an unknown proportion of hatchery fish, in the 1950s and early 1960s, including adults trapped at Minto.

4.6.2 Current Status of Native Anadromous Salmonids within the Subbasin

4.6.2.1 UWR Chinook Salmon

Population Viability

The North Santiam population of UWR Chinook is considered to be at a high risk of extinction (with considerable certainty) based on an assessment of its abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). Chronically unfavorable conditions within a reduced geographic distribution create much of this risk, but the potential for catastrophic events such as landslides, hatchery-related disease outbreaks, or volcanic events, is also a contributor.

Abundance & Productivity

The North Santiam Chinook population’s limited abundance and productivity pose a very high risk of extinction (McElhany et al. 2007). Pre-spawn mortality rates are high, abundances of successful natural-origin (wild) spawners are low, and recent use of natural spawning areas has been dominated by fish of hatchery origin (Schroeder et al. 2006). The wild component of the spawning population is not thought to be self-sustaining (Good et al. 2005).

Adult UWR Chinook returning to the North Santiam River are counted as they pass over Bennett Dam (at RM 31.5) and later if they are captured in a fish trap (Minto Trap) at a hatchery barrier dam about 3 miles below Big Cliff. Figure 4.6-3 gives the numbers of adult Chinook salmon counted at Minto Trap (above all natural spawning areas accessible to the North Santiam population) each year from 1981-2006. Fish arriving at the trap are predominantly hatchery fish, but the extent to which hatchery fish outnumber natural-origin (wild) ones at the trap has only become certain within the last decade as improvements have been made to fish marking and monitoring efforts in the Willamette Basin. Annual counts of adult UWR Chinook at Minto Trap have risen erratically since the early 1980s, perhaps in part due to more effective collections of the fish that accumulate at the barrier dam, and averaged 3,887 fish during the most recent 5-year period. An average of 239 (6%) of the fish counted at the trap during this recent period were classified as wild (McLaughlin et al. 2008). These wild fish were either incorporated into the local hatchery broodstock or released into spawning areas on the Little North Santiam River (McLaughlin et al. 2008).

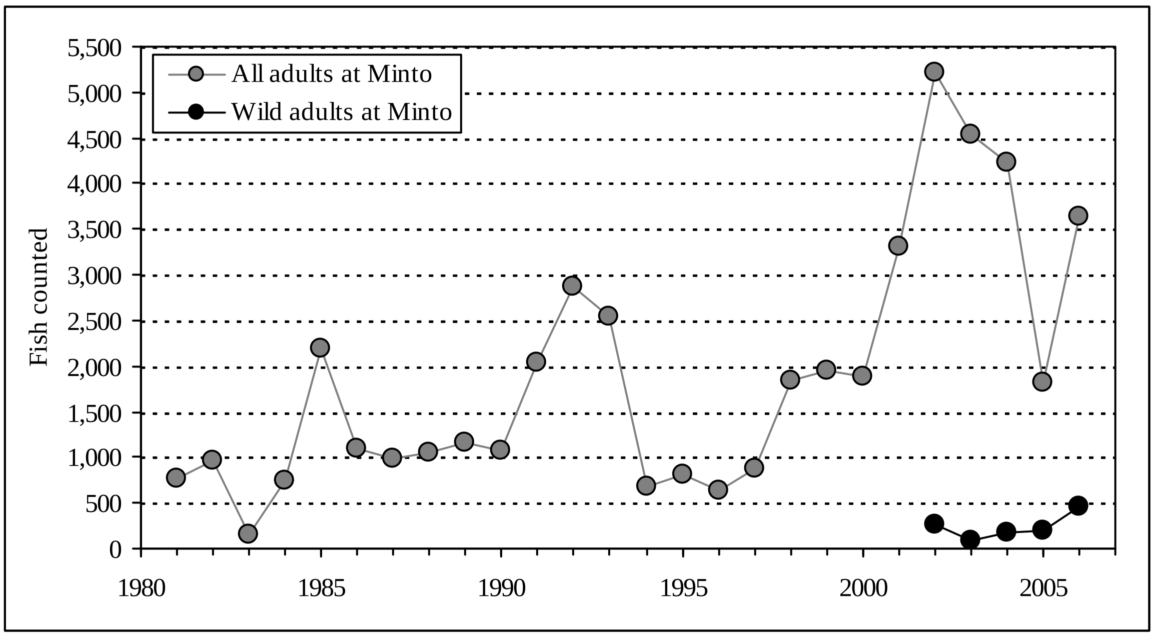


Figure 4.6-3 Annual returns of spring Chinook salmon to Minto Trap on the North Santiam River at RM 31.5 from 1984-2006 (StreamNet trend no. 50969), including 2002-2006 estimates of the wild component that were developed by McLaughlin et al. (2008).

During 2001-2005, the most recent 5-year period for which annual counts of UWR Chinook passing over Bennett Dam are available, numbers of wild adults ranged from 220 to 667 and averaged 450 fish (McLaughlin et al. 2008, Table 4.6-1). These wild fish accounted for an average of 6% of all adults passing the dam during this period, the same fraction seen recently in the catch at Minto Trap (see above). Wild fish passing Bennett Dam but not later counted at Minto Trap either spawn successfully in the North or Little North Santiam Rivers or die prior to doing so.

Table 4.6-1 Estimated numbers of wild and hatchery-origin adult UWR Chinook passing upstream at Bennett Dam, North Santiam River, 2001-2005, as determined by analyses of otoliths in non fin-clipped fish and coded wire tags in fin-clipped fish (McLaughlin et al. 2008).

Year	Number of wild adults	Number of hatchery-origin adults	Total adults passing upstream at Bennett Dam	Percent wild
2001	220	6,566	6,786	3
2002	604	7,036	7,640	8
2003	271	12,561	12,832	2
2004	489	13,042	13,531	4
2005	667	4,216	4,883	14
5- year average	450	8,684	9,134	6

Under contract to the USACE, ODFW has since 2001 conducted intensive monitoring of the spawning grounds of UWR Chinook in the North Santiam and Little North Santiam rivers. Monitoring results from 2001 through 2006 showed that annual pre-spawn mortality rates of these fish were high in both the North Santiam (mean = 59%) and Little North Santiam (mean = 51%), and that an average of 90% of the spawners along the mainstem and 49% of those in the Little North Santiam were of hatchery origin (McLaughlin et al. 2008). Further, the numbers of successful spawners appear likely to have included an average of fewer than 100 wild adults in each river. Extended over the long term, the combination of low abundance of wild adults, high pre-spawn mortality, and high percentages of hatchery fish in spawning areas, would make it improbable that the river's “wild” run could include many individuals more than a few generations removed from the hatchery.

Recent counts of UWR Chinook redds (nests) in known spawning areas on the North Santiam and Little North Santiam rivers are given in Table 4.6-2. An average of 302 redds (range: 144-661) has been counted annually in the two rivers from 1997 through 2006, with nearly 90% of these redds seen in the North Santiam (ODFW 2007a).

The intensity of UWR Chinook use of spawning areas within the North Santiam itself is strongly skewed toward the reach of river immediately below the barrier dam at Minto (Schroeder et al. 2006). The concentration of spawners in areas relatively closer to Big Cliff would seem to increase the potential for the USACE dams and their reservoirs to affect fish survival (hence productivity) by influencing water quality, flow, or physical habitat conditions.

Table 4.6-2 Counts of spring Chinook salmon redds in the North Santiam and Little North Santiam rivers, 1997-2006 (ODFW 2007a).

Year	North Santiam R. (Stayton to Minto)	Little North Santiam R.	Total
1997	134	10	144
1998	155	39	194
1999	215	11	226
2000	272	22	294
2001	308	18	326
2002	276	30	306
2003	630	31	661
2004	283	51	334
2005	240	61	301
2006	202	34	236
10-year average	272	31	302

Spatial Structure

The reduced access of spring Chinook in the North Santiam subbasin to high-quality habitats reflects a high or very high extinction risk. Mattson (1948) estimated that 71% of the spring Chinook production in the North Santiam subbasin occurred above the current sites of USACE dams. More recently, ODFW (2005b) estimated that 42% of the historically suitable habitat for spring Chinook is now inaccessible. However, the now inaccessible areas were high quality habitats, and the primary spawning areas in the North Santiam (McElhany et al. 2007). Much of the remaining habitat is not well-suited for spring Chinook, although some favorable reaches may still be found in the Little North Santiam.

Diversity

Diversity-related risks posed by losses of life history traits, low effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity, can affect the viability of salmonid populations. McElhany et al. (2007) considered such risks to pose a high risk of extinction for the North Santiam population of UWR Chinook. Their primary concerns in this regard included known changes in spawn, emergence, and juvenile migration timing (Myers et al. 2002), the small size of the naturally-produced spawning component, and the potential for hatchery domestication.

4.6.2.2 UWR Steelhead

Population Viability

McElhany et al. (2007) have rated the North Santiam population of UWR steelhead as being at low to moderate risk of extinction with considerable uncertainty, based on an assessment of its abundance, productivity, spatial structure, and diversity. Key chronic risk factors include reductions in spatial structure caused by USACE dams, reduced habitat diversity, genetic legacies of past hatchery programs, and potential competition from the juvenile offspring of hatchery-produced summer-run steelhead of non-native stock. Catastrophic risks, including landslides, disease epidemics from hatchery releases into the system, and volcanic activity (from Mt. Jefferson), also contribute (WLCTRT 2003).

Abundance & Productivity

McElhany et al. (2007) classified the winter-run steelhead population in the North Santiam subbasin as facing a low extinction risk based on its abundance and productivity, though they expressed a high degree of uncertainty. The population is relatively large, with a long-term (1980-2005) geometric mean abundance of 2,722 natural-origin spawners and a short-term (1990-2005) geometric mean abundance of 2,109 (McElhany et al. 2007).

The abundance of late-run winter steelhead in the North Santiam subbasin has been monitored most effectively by counting redds within a sub-sample of available spawning areas. Figure 4.6-4 gives estimates that Chilcote (2007) developed of the annual abundance of spawners from 1980 through 2005 that are somewhat uncertain but form the basis of viability analyses by McElhany et al. (2007). The estimates suggest a mean annual abundance of 4,499 spawners during the most recent five years in the time series after a period of relatively lower abundance during the 1990s.

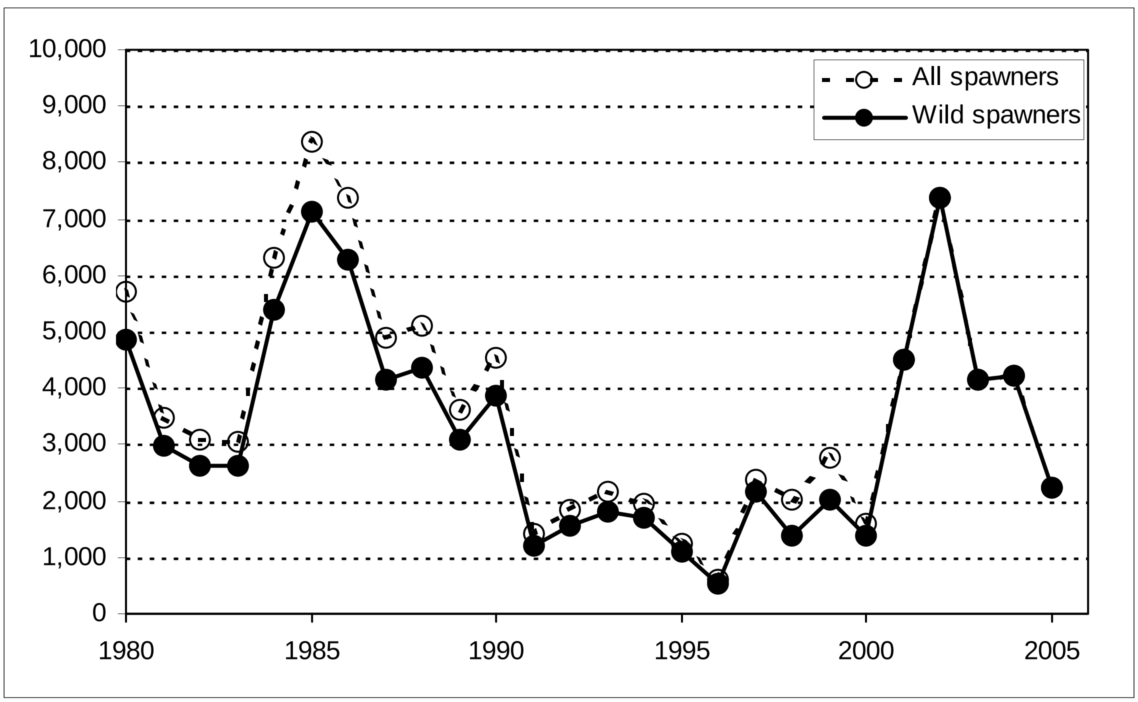


Figure 4.6-4 Estimates of the annual numbers of adult native late-winter steelhead of all (wild plus hatchery) and wild origin that spawned in streams within the North Santiam subbasin, 1980-2005 (data source: Chilcote 2007).

An additional index of the annual abundance of late-winter steelhead adults in the North Santiam subbasin is available from counts made at Bennett Dam on the lower North Santiam River, downstream of most natural spawning areas (Table 4.6-3). The Bennett Dam counts may exhibit negative bias related to how passage estimates are expanded to account for days when fish movements through the fish ladder are not monitored (Firman et al. 2005. The Bennett counts suggest an average of 2,396 adults passing the dam during the same 2000-2004 period for which the Chilcote (2007) time series suggests an average of 4,367 wild adults in the subbasin as a whole.

Table 4.6-3 Estimated number of late-winter steelhead passing Bennett Dam on the North Santiam River, 1998-2004 (data source: Firman et al 2005).

Year	Winter steelhead passage estimate for Bennett Dam
1998	1,409*
1999	1,111*
2000	1,448*
2001	3,639
2002	2,694
2003	1,261
2004	2,939
5 year average (2000-2004)	2,396

* Counts affected by hatchery-origin returns to the North Santiam subbasin.

Spatial Structure

McElhany et al. (2007) have classified the current spatial structure of the North Santiam steelhead population as most likely reflective of a population with a moderate to high risk of extinction, due substantially to blocked access to historically important habitats above USACE dams. Since 1953, winter steelhead have been restricted to that portion of the North Santiam subbasin below Big Cliff Dam. The fish now spawn in the mainstem above the Minto weir (to Big Cliff Dam) and downstream of the weir, as well as in tributaries that include the Little North Santiam River, Mad Creek, and Rock Creek.

Tributaries to the upper Little North Santiam River, such as Elkhorn Creek and Sinker Creek, are also used extensively. ODFW (2005b) estimates that 46% of the historically suitable habitat is now inaccessible. The blocked areas include some of the subbasin's most productive habitats for this species (McElhany et al. 2007).

Diversity

McElhany et al. (2007) considered available information on the life history traits, effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity of North Santiam winter steelhead and suggested the population's diversity reflects a moderate risk of extinction. The authors' primary concern was the potential effect on life history diversity of the loss of higher elevation spawning areas above the USACE dams.

4.6.2.3 Limiting Factors & Threats to Recovery

Factors unfavorably affecting the status of the North Santiam populations of UWR Chinook and UWR Steelhead have been summarized by ODFW (2007b) and are given in Table 4.6-4. Key limiting factors and threats to both species include a variety of dam effects, large hatchery programs developed partly to help offset dam effects, and the cumulative effects of multiple land and water use practices on aquatic habitat. For the spring Chinook in particular, USACE dams that lack effective passage facilities prevent wild fish from using historically important habitats on Federal lands in upper portions of the subbasin and force a severely diminished population to rely upon habitats below Big Cliff Dam that have been structurally, hydrologically, and thermally altered. These altered habitats often contain hatchery produced salmonids, or their direct offspring, that may compete or interbreed with the wild fish.

In all, 6 of 11 primary and 6 of 12 secondary within-subbasin limitations on the recovery of these two ESA-listed populations are related to USACE dams or programs (ODFW 2007b, Table 4.6-4).

Table 4.6-4 Key and secondary limiting factors and threats to recovery of North Santiam Spring Chinook and Winter Steelhead (ODFW 2007b).

		North Santiam Subbasin (Streams and Rivers within Population Area)								
Threats	Species	Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt
Harvest	Chinook									
	Steelhead									
Hatchery	Chinook			4b 6c					3	
	Steelhead			4c	4d				3	
Hydropower/ Flood Control	Chinook	9b 7b		10d			1d	2b 2k	7c	
	Steelhead	10a 9d 7b		10d			1d	2b	7c	2i
Landuse	Chinook			8a	8a 9a	8a		2f		
	Steelhead	7a		9a 10b 2a		8a				
Introduced Species	Chinook									
	Steelhead									

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key threats and limiting factors

- 1d Mortality at North Santiam hydropower/flood control dams due to direct mortality in the turbines and/or smolts being trapped in the reservoirs.
- 2b Impaired access to habitat above North Santiam hydropower/flood control dams.
- 2f Impaired access to habitat above Upper and Lower Bennett dams.
- 3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.
- 4c Competition with naturally produced progeny of hatchery summer steelhead.
- 4d Competition with residualized hatchery summer steelhead smolts.
- 8a Impaired physical habitat from past and/or present land use practices.

9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
9b Elevated water temperatures below the North Santiam hydropower/flood control dams resulting in premature hatching and emergence.
10a Elevated flows during spawning and dewatering of redds below North Santiam hydropower/flood control dams.
10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

Secondary threats and limiting factors

2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.
2i Impaired downstream passage at North Santiam hydropower/flood control dams.
2k Prespawning mortality due to crowding below North Santiam hydropower/flood control dams.
4b Competition with naturally produced progeny of hatchery spring Chinook.
6c Predation by hatchery summer steelhead smolts.
7a Fine sediment in spawning gravel from past and/or present land use practices.
7b Streambed coarsening below North Santiam hydropower/flood control dams due to reduced peak flows.
7c Lack of gravel recruitment below North Santiam hydropower/flood control dams due to gravel capture in upstream reservoirs.
8a Impaired physical habitat from past and/or present land use practices.
9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
9d Cool water temperatures below North Santiam hydropower/flood control dams impede development or growth.
10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.

4.6.3 Environmental Conditions

4.6.3.1 Habitat Access

Access to large portions of once-productive habitat for spring Chinook and winter steelhead is blocked by the USACE's Detroit and Big Cliff dams (McElhany et al. 2007). The importance of safe access to historical habitats and the relationship of such access to the requirements of UWR Chinook salmon and steelhead are described in detail in Appendix E. Basically, the subbasin's naturally produced UWR Chinook and steelhead need access to historical habitat because what is left to them downstream of the dams is of lesser quality, appears insufficient by itself to support strongly viable populations, and must often be shared with fish from massive hatchery-based mitigation programs that may reduce natural productivity through competition, disease transmission, or (in the case of spring Chinook) unfavorably high levels of interbreeding.

4.6.3.1.1 Migratory Obstacles below Big Cliff Dam

McIntosh et al. (1995) described several artificial obstructions in the North Santiam River below the current site of Big Cliff Dam, based on an August 1940 survey by Parkhurst and Bryant. These included early configurations of the diversions and canals near Stayton, owned by the Santiam Water Control District (SWCD) and City of Salem, which are used for irrigation and hydroelectric production. Upper Bennett Dam, located at RM 31.5, splits the river into North and South channels and diverts water into the North Channel. Lower Bennett Dam is located on the North Channel (about RM 29 of the North Santiam) and directs water towards the SWCD Power Canal, located downstream. Water that does not enter the Power Canal headgate flows over a third dam, the Spillway Dam, and is returned to the North Santiam River via the North Channel. The Spillway Dam contains a fish ladder, and the headgate also contains a fish ladder to return adults migrating up the SWCD Power Canal before returning to the North Santiam River.

Some of the passage impacts, unrelated to flow, have been addressed. The City of Salem installed a new fish ladder at Upper Bennett Dam in 2006 to improve upstream migration and reduce delay. The City may be replacing the existing fish ladder at Lower Bennett Dam in the future, but has no specific plan or dates for construction. The SWCD completed installation of a fish screen and tailrace barrier in the SWCD Power Canal in 2004. Thus, anadromous fish can no longer enter the SWCD Power Canal from either direction. NMFS determined that this proposal would not jeopardize listed Chinook salmon and steelhead in its March, 2003, biological opinion (NMFS 2003b). However, the flow related impacts associated with this project continue:

- In 20% of the 50 years for which there are relevant flow data, diversions into the North Channel left less than 25% of the width of the South Channel available for upstream passage by adult Chinook salmon during July and August. (NMFS 2003b)
- When the Rousch and Water Street hydroelectric facilities are operating and flow is diverted for irrigation purposes, the majority of river flow from the North Santiam is diverted into the North Channel and then into the Power Canal, leaving as little as 50 cfs in the North Channel.

In addition to these ongoing impacts, in 2007 the SWCD applied for an exemption to operate the Stayton Hydroelectric Project again, which would increase diversions into the SWCD Power Canal by as much as 760 cfs (up to 1,100 cfs total diversion). This additional diversion would further decrease available flows in this section of the North Santiam River.

Several other diversions within the same reach present hazards for downstream migrating Chinook salmon and steelhead. Just upstream from Lower Bennett Dam and the SWCD Power Canal, the unscreened Salem Ditch diverts up to 100 cfs from the North Channel of the North Santiam River to Mill and Pringle creeks, which flow through the City of Salem prior to joining the mainstem Willamette River. The City of Salem also withdraws up to 116 cfs (with a water right for 227 cfs) from an intake on the North Channel of the North Santiam River for its municipal water supply. The City of Salem installed screens on its municipal intake in 1998 that were designed to meet NMFS' criteria.

The Salem Ditch, the City of Salem municipal intake, and the other irrigation withdrawals can limit the abundance, productivity, and behavior of listed Chinook and steelhead in many ways:

- Juveniles and downstream-migrating smolts and kelts can be entrained into the unscreened Salem Ditch and then into Mill or Pringle Creeks. Thirty to 50 cfs of water from the Salem Ditch and Mill Creek is diverted into the unscreened Salem Mill Race, which supplies a historic hydroelectric plant, Mission Mill, in the City of Salem. The City of Salem completed ESA consultation with NMFS in 2003 regarding its proposal to install a fish exclusion screen at the Mill Race (NMFS 2003b).
- Water diverted from the North Santiam River via the Salem Ditch enters the Willamette River via Mill Creek and Pringle Creek. Adult fish migrating upstream in the mainstem Willamette could delay at the mouths of (or attempt passage up) these two creeks, where they detect the scent of the North Santiam River. The City of Salem is currently in consultation with NMFS to address further increased municipal withdrawals.
- The numerous withdrawals from the North Santiam River in the vicinity of Geren Island dramatically decrease flow in the North Santiam River during summer, particularly in the South Channel below Upper Bennett Dam. Low water levels could delay migrating adult Chinook and limit spawning and rearing in this reach.

There are numerous smaller diversions in the 15 miles of the North Santiam River downstream of the SWCD project and in the main Santiam River below the confluence with the South Santiam. Information is not available on juvenile fish screening at these diversions (USACE 2000).

On the Little North Santiam River, Salmon Falls (also sometimes referred to as Elkhorn Falls) blocks adult fish passage at RM 16. A fish ladder installed in 1958 has allowed passage of adult UWR Chinook salmon and steelhead up to the next impassable falls (at RM 24). The ladder has been used more frequently by steelhead than Chinook (BLMS 1998). A total of 514 adult UWR steelhead were counted at this ladder in 1963 (Thompson et al. 1966).

During construction of Detroit and Big Cliff dams in the early 1950s, a concrete weir (Minto Dam) was built about three miles downstream of the dams to replace the old hatchery rack. Minto Dam has blocked volitional passage of all adult spring Chinook salmon and most winter steelhead to the three mile section of river immediately downstream of the site of Big Cliff Dam since 1952.

4.6.3.1.2 Fish Passage at the Detroit/Big Cliff Project

The USACE's Big Cliff Dam (RM 58.1) and Detroit Dam (RM 60.9), both completed in 1953, form a complete barrier to upstream fish passage. The ODFW has, on occasion, released hatchery-reared fingerling Chinook into Detroit Reservoir (i.e., to augment the recreational trout fishery) (Mamoyac and Ziller 2001). Preliminary screw trap studies indicate a survival rate for these juveniles past the concrete at Detroit Dam of approximately 51% to 60.5%. The survival rate at Big Cliff Dam was approximately 69%, indicating a combined survival rate for fish that pass both dams of approximately 35% to 42% (Ziller et al. 2002). There are no estimates of reservoir survival for juvenile salmonids at the Detroit/Big Cliff Project, but concerns about predation by northern pikeminnow are low due to cold water temperatures above Detroit Dam. Combined with early hatchery operations, the dams have reduced the geographic distribution of spring Chinook salmon and winter steelhead and thus limited the abundance and productivity of the naturally-spawning populations. They have also increased the risk of losing these populations to natural or man-made catastrophes that may affect the mainstem downstream of the USACE dams.

Since 1998, many adult spring Chinook of hatchery origin have been collected at the Minto Trap and out-planted into the North Santiam River between the trap and Big Cliff Dam, and into areas above Detroit Dam, to begin re-establishing fish access to blocked natural spawning areas (Table 4.6-5). During the most recent five-year period for which data are available (2002-2006), annual releases have averaged 250 hatchery-origin adults into the North Santiam between Minto and Big Cliff Dam, 1,948 into the North Santiam River above Detroit Reservoir, and 144 into the Breitenbush River (Beidler and Knapp 2005; McLaughlin et al. 2008). Releases into the Breitenbush have been inconsistent.

Year	N. Santiam R. above Minto Trap	N. Santiam R. above Detroit Reservoir	Breitenbush River
1998	1,155	0	0
1999	1,098	0	0
2000	967	707	226
2001	292	540	528
2002	729	1,680	893
2003	203	1,869	1,017
2004	144	1,689	822
2005	30	614	0
2006	143	1,123	720
5-year avg. (2002-2006)	250	1,948	144

Table 4.6-5 Numbers of adult Marion Forks Hatchery spring Chinook released into areas blocked by dams in the North Santiam subbasin, 1998-2006. Sources: Beidler and Knapp 2005; McLaughlin et al. 2008).

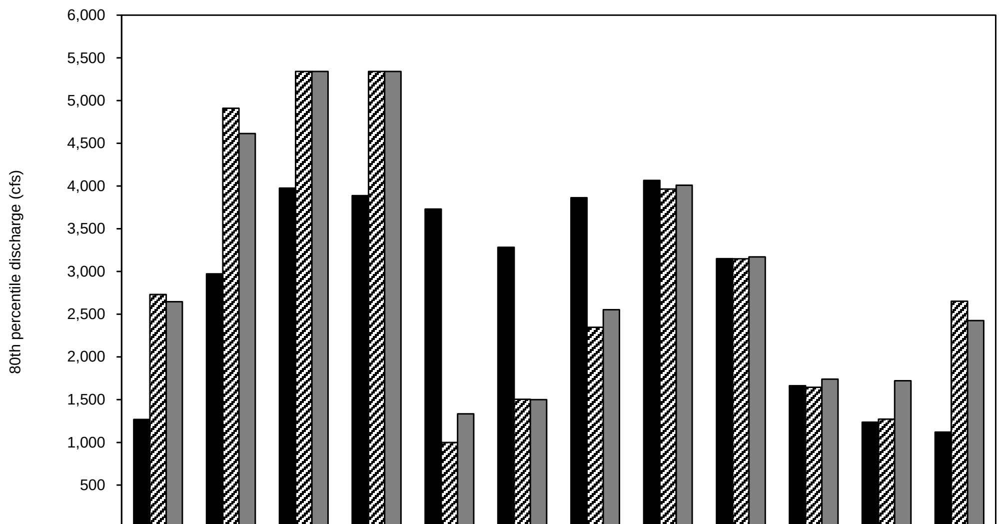
ODFW conducted limited snorkel surveys in the late 1990s and early 2000s during summer months in the North Santiam above Detroit reservoir, in the Breitenbush River above Detroit, below Big Cliff Dam, and in the Little North Santiam River below Big Cliff Dam (Beidler and Knapp 2005). ODFW documented significant juvenile production in the Breitenbush River and the North Santiam above Detroit, with much less production evident in the North Santiam below Big Cliff Dam. Extremely few juveniles were observed in the Little North Santiam, but this could be a result of high pre-spawning mortality. Firman et al (2004) estimated 93% of the outplanted females died prior to spawning in 2003, and similar results have been documented in other years. Additionally, it is possible that the Little North Santiam is suited to produce ocean-type fish, meaning that most juveniles would emigrate downstream as fry, leaving few to be observed during summer snorkel surveys.

4.6.3.2 Water Quantity/Hydrograph

The general relationships between flow, hydrology and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E. Table 4.6-8 summarizes habitat characteristics of flow and hydrology in the North Santiam subbasin under the environmental baseline, which is also described in more detail below.

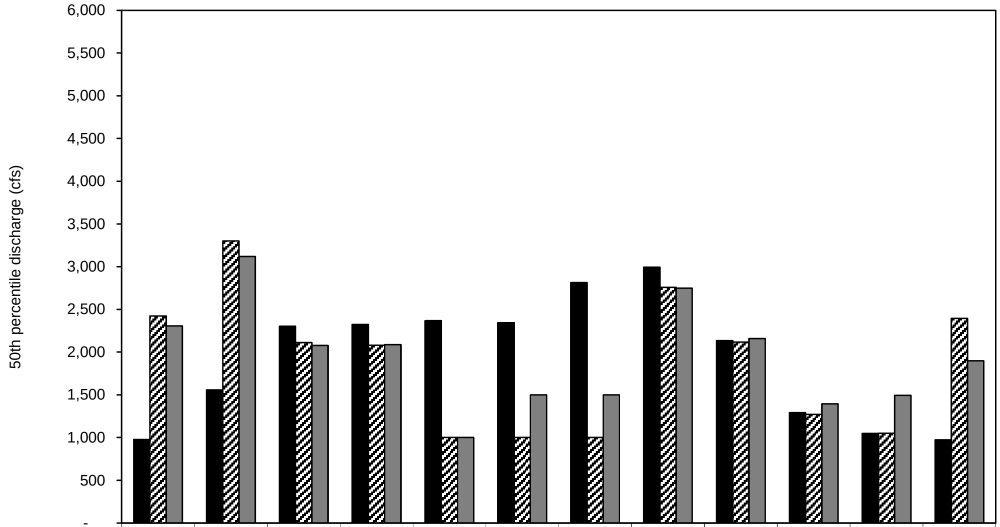
Human-caused alterations of the hydrologic regimes of the lower North Santiam River and its principal tributaries have generally diminished flow-related habitat quantity and quality and have probably reduced the numbers, productivity, and life history diversity (adult run timing and juvenile outmigrant strategies) of spring Chinook salmon and winter steelhead, and limited the production potential of accessible habitat in much of the subbasin. Within the lower North Santiam itself, the effect of Project operations has been to control flood peaks, reduce spring and early summer flows, and increase late summer and fall flows (Figures 4.6-5 A, B & C).

Figures 4.6-5 A, B & C Simulated discharge (cfs) of North Santiam River at Niagara, Oregon under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



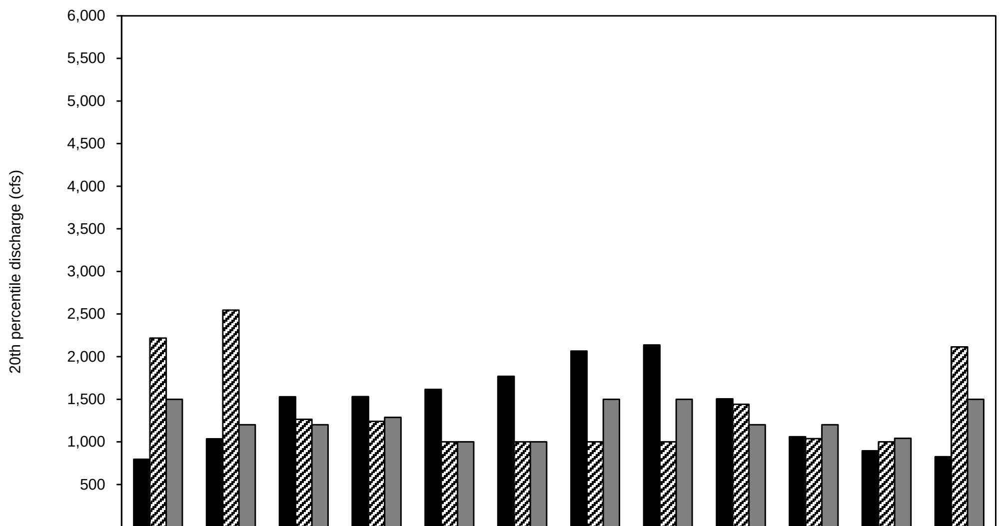
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	1,269	2,971	3,977	3,887	3,731	3,284	3,865	4,066	3,150	1,664	1,235	1,119
Pre-2000	2,732	4,910	5,340	5,340	1,000	1,504	2,346	3,965	3,147	1,643	1,271	2,651
Post-2000	2,645	4,614	5,340	5,340	1,335	1,500	2,552	4,010	3,170	1,741	1,720	2,427

Figure 4.6-5 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	977	1,558	2,301	2,323	2,368	2,346	2,815	2,994	2,135	1,291	1,048	972
Pre-2000	2,422	3,301	2,112	2,081	1,000	1,000	1,000	2,759	2,118	1,270	1,050	2,394
Post-2000	2,306	3,119	2,078	2,086	1,000	1,500	1,500	2,750	2,158	1,395	1,494	1,898

Figure 4.6-5 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	796	1,034	1,530	1,533	1,617	1,769	2,064	2,136	1,503	1,061	896	826
Pre-2000	2,218	2,545	1,265	1,239	1,000	1,000	1,000	1,000	1,441	1,038	1,000	2,114
Post-2000	1,500	1,200	1,200	1,287	1,000	1,000	1,500	1,500	1,200	1,200	1,041	1,500

Figure 4.6-5 C

Low flows are a natural occurrence in the North Santiam River and its tributaries but the degree, timing, and frequency of low flows have been affected by Detroit and Big Cliff project operations and an array of downstream mainstem and tributary water developments. Detroit and Big Cliff operations have reduced the minima seen in the lower North Santiam River during late winter and spring months. As a result, it is likely that the available habitat for juvenile Chinook and steelhead rearing is also reduced. In some systems, recruitment of age 0 rainbow trout (*O. mykiss)* has been found to be directly correlated with late winter flows (Mitro et al. 2003).

The increase in late summer and fall flows provided by flow augmentation operations at Detroit and Big Cliff dams probably benefits juvenile salmonids by increasing habitat area and reducing the rate at which water temperature responds to thermal loads. Water released at Big Cliff Dam tends to be cooler than inflows during midsummer, further cooling the river during that period (Figure 4.1-3). Increased fall flows associated with reservoir drafting (to create flood storage space) may affect spring Chinook spawning downstream from Big Cliff Dam by increasing the available habitat area. However, nests created at higher elevations would be vulnerable to dewatering during sudden reductions in discharge.

The OWRD has established instream flow water rights in five watersheds within the North Santiam subbasin (North Santiam River at its mouth, Stout Creek at its mouth, North Santiam River upstream of Little North Santiam River, Rock Creek at its mouth, and Mad Creek at its mouth) to support aquatic life (E&S 2002). However, because these instream flow water rights are junior to nearly all water uses in the basin they primarily protect aquatic life from further degradation. Diversions for irrigation, power generation and domestic and industrial water uses from the mainstem near Stayton, well downstream of Big Cliff Dam, and in some of the lower river's tributaries, exacerbate low flow conditions in late summer and early fall. Low summer flows limit juvenile rearing habitat and sudden increases in diversion rates can entrap and strand juveniles rearing in the vicinity. High rates of water consumption in the lowermost North Santiam River and Stout Creek indicate the potential for substantial reductions in habitat area and production potential for anadromous fish. The effects of diversion-caused flow reductions in the mainstem North Santiam are somewhat offset during July, August, and September by releases of stored water at Detroit and Big Cliff reservoirs to meet tributary and mainstem Willamette minimum flow objectives (section 2.8, Table 2-8 and 2-10) as well as to ensure reservoir drawdown in the fall for flood control.

Water in the North Santiam River is used extensively by agriculture, municipalities, power generators, and industries. The OWRD has issued permits for surface water withdrawals for 2,730 cfs from the North Santiam River (OWRD 2003). This is a maximum allowable diversion right, and actual diversions have been lower, by perhaps half, at any particular time. Much of the diverted water is used for hydroelectric power purposes and is returned to the river downstream from the point of diversion.

The OWRD water availability process (OAR 690-400-011) has determined that natural flow is not available for out-of-stream use from the North Santiam River during the months of August and September. Further, the Willamette Basin Program Classifications regulation (OAR 690-502-0110) requires that new summer surface water users in the sub-basin (e.g., irrigators) obtain water service contracts from Reclamation for use of water stored in Willamette Project reservoirs. As of March 2007, Reclamation had contracted a total of 9,474 acre-feet of water stored in Detroit and Big Cliff reservoirs to irrigators along the North Santiam River (USACE 2007a), which constitutes a small fraction of the surface water withdrawals issued by OWRD. Another 1,485 acre-feet are contracted from storage in Detroit and Big Cliff reservoirs (as well as some storage from Green Peter and Foster reservoirs in the South Santiam River) to users diverting from the mainstem Santiam River downstream from the confluence of the North and South Santiam Rivers.

The Santiam Water Control District, the primary water provider in the basin, and the City of Salem, own a series of structures (including Upper and Lower Bennett dams) near Stayton, Oregon, that divert water for irrigation, hydroelectric power production, and municipal water supplies. The City of Salem currently diverts up to 102 cfs (with a water right for up to 227 cfs) from the North Santiam River just upstream of the SWCD project area for its municipal water supply. There are numerous smaller diversions in the 15 miles of the North Santiam River downstream from the SWCD project and in the 11 miles of the mainstem Santiam River downstream from the confluence with the South Santiam.

The Stayton complex of dams and diversions has been shown to delay adult salmon passage when total river flows are less than about 555 cfs downstream from Bennett Dam (ODFW 1994; Schreck et al. 1994). Passage problems at the complex are most common in May. With the maximum allowable diversion rate of about 900 cfs at the Stayton complex, total river inflows of 1,455 cfs at the upstream end of the complex would be needed to minimize passage delays at the maximum allowable diversion rate. By storing water during the spring, Detroit and Big Cliff reservoirs therefore increase the potential for adult migration delay at the Stayton complex. The (screened) large-scale diversions in the Stayton area where low flow conditions have been common are of particular concern.

There has been very little water development in the basin upstream of Detroit Dam (upper North Santiam basin), but water development has severely depleted flows in the North Santiam River downstream from Stayton, Oregon, and in Stout Creek. E&S (2002) rated the dewatering potential at the mouth of the North Santiam River as “moderate” (26.6% of flow consumed) and at the mouth of Stout Creek (a tributary to the lower river) as “high” (38.8% of flow consumed).[1]

4.6.3.2.1 Peak Flow Reduction

Reductions in peak flows caused by flood control operations at Detroit and Big Cliff dams have contributed to the loss of habitat complexity in the North Santiam River by substantially reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods.[2] Over time, flood control reduces channel complexity (e.g., reduces the number of side channels, and diminishes woody debris recruitment) and reduces the movement and recruitment of channel substrates (Appendix E). Side channels, backwaters, and instream woody debris accumulations have been shown to be important habitat features for rearing juvenile salmonids.

Prior to dam construction, the highest instantaneous peak flow recorded at Niagara, 0.8 miles below Big Cliff Dam, was 63,200 cfs (Hubbard et al. 1997) and flows greater than 40,000 cfs were common (USACE 2000). Since project completion, the maximum instantaneous flow in this reach has been 18,700 cfs. Unregulated inflows from tributaries such as the Little North Santiam River continue to produce flood events in the lower mainstem North Santiam (BLMS 1998). For example, flows as high as 67,200 cfs have been recorded at the USGS’ Mehama gage, 0.5 miles below the mouth of the Little North Santiam. However, even with this influence

[1] These assessments are based on the fraction of each stream’s 80% exceedence discharge (the rate of flow that is exceeded 80% of the time during the summer months) that is consumed by various uses.

[2] Bank stabilization measures and land leveling and development are also responsible for reducing channel complexity and associated juvenile salmon rearing habitat (Appendix E).

and at a distance 20 miles below Big Cliff Dam, the magnitude of the two-year recurrence interval event has decreased from 34,200 to 19,700 cfs.

Controlling peak flows inhibits the flushing of fine sediments that accumulate on the river bed. Interstitial sediments finer than 1 mm can reduce intragravel flow and the supply of oxygenated water to incubating eggs (Kondolf and Wilcock 1996). Somewhat coarser sediments (1 to 9 mm diameter) can fill interstices and physically block emergence of fry from the bed. Aquatic invertebrates occupy open spaces in cobbles and gravel, and fine sediment can eliminate this habitat. The potential reduction in interstitial spaces may also affect juvenile salmonids which are known to use interstitial spaces for cover during winter periods (Bjornn and Reiser 1991). The significance of these effects in the North Santiam River downstream from Big Cliff Dam is unknown but probably diminishes in a downstream direction as flows and sediments enter the river from unregulated tributaries.

Controlling peak flows also reduces the potential for redd scouring. Spring Chinook would be more likely to benefit from this effect than steelhead because their eggs are incubating through the winter months when floods are most likely and the reservoir space necessary for flood attenuation most available. However, the rate at which flows would be reduced during flood control operations is also a factor (see below).

4.6.3.2.2 Altered Flow Effects on Spawning Success

There is concern that the difference between Project-elevated flows in the lower North Santiam River during late summer and early fall when spring Chinook select spawning sites, and the minimum flows discharged during active flood control operations during winter may dewater salmon redds prior to fry emergence (Ross 2008). Depending on the duration and rate of desiccation, dewatering salmon redds can kill incubating eggs and alevins (Reiser and White 1983). It can also cause entrapment and stranding of newly emerged salmonids. The potential for these Project-related effects is probably greatest near Big Cliff Dam and diminishes downstream as water from unregulated tributaries enters the river.

4.6.3.2.3 Flow Fluctuations, Entrapment & Stranding

The North Santiam River downstream from Big Cliff Dam was historically subject to rapid water level fluctuations, particularly during active flood control operations when discharge dropped sharply to prevent downstream flooding. Discharge levels in the lower river have also fluctuated as a consequence of power generation, though Big Cliff Dam is operated to limit such occurrences. Load-following or ‘peaking’ operations (i.e., timing discharge through the turbines to coincide with the demand for energy generation) result in rapid changes in discharge rates from the turbines at Detroit Dam ranging between 0 and 5,340 cfs. Such changes in discharge occur routinely into the approximately one-mile reach of the North Santiam River above Big Cliff Reservoir, with no restrictions on ramping rates because this area is generally inaccessible to migratory fish. Operations at Big Cliff re-regulate discharge fluctuations from load-following operations at Detroit. This re-regulating operation causes the elevation of Big Cliff Reservoir to fluctuate as much as 24 feet daily while keeping discharge rates to the North Santiam River fairly constant.

The USACE has since 2006 limited maximum down-ramping rates below Big Cliff Dam to 0.1 ft/hour during nighttime and to 0.2 ft/hour during daytime unless such restriction has been infeasible with existing equipment at the dam (USACE 2007a). The result has been adherence to these downramp rates at moderate to moderately low river flows, but not at high or prescribed minimum flows. Maximum up-ramping rates vary from 500 cfs per hour at initial flows between 100 and 1,000 cfs to 2,000 cfs per hour at initial flows above 17,000 cfs.

During winter flood events, as well as during emergency events that may occur at any time of the year, juvenile Chinook salmon and steelhead could be stranded and entrapped below Big Cliff Dam, particularly as flows approach the prescribed minimums. The physical effect of down-ramping is most pronounced immediately below Big Cliff Dam and decreases in a downstream direction as pulses in flow attenuate and water from unregulated tributaries enters the river.

4.6.3.3 Water Quality

The general relationships between water quality and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E. Generally, ODEQ monitoring indicates that water quality in the North Santiam River is excellent (Mrazik 2006). The characteristics of water quality and its status in the North Santiam subbasin under the environmental baseline are summarized in Table 4.6-8 and described in more detail below.

4.6.3.3.1 Water Temperature

Water temperatures in streams used, or once used, by UWR Chinook or UWR steelhead within the North Santiam subbasin are subject to a variety of human-caused influences, including the USACE dams on the mainstem North Santiam River.

Water Temperatures Unaffected or Relatively Unaffected by USACE Dams

Human activities have affected maximum summer water temperatures in areas of the subbasin not affected by Willamette Project operations. The maximum temperatures for rearing, and adult and juvenile migration have been exceeded in streams above Detroit Reservoir (Marion Creek), and in tributaries to the lower reaches of the North Santiam (Chehulpum Creek, Bear Branch, and the Little North Santiam River, including Stout and Elkhorn creeks) (ODEQ 2006a). A week-long exposure to the high temperatures recorded in the Little North Santiam River, and in the mainstem Santiam River below the confluence of the North and South Santiam rivers (i.e., >73.4°F [>23°C]), could subject juvenile Chinook salmon and steelhead to lethal conditions (Appendix E, Table E-2), directly reducing juvenile outmigrant production and indirectly limiting population abundance and productivity.

Water Temperature Effects of the USACE Dams

Operations at Detroit and Big Cliff dams have altered seasonal thermal regimes in the North Santiam River (Figure 4.6-6). Because the water released at Detroit Dam is drawn from near the bottom of the reservoir, discharge temperatures are up to 5.4 to 9°F (3 to 5°C) cooler than inflow temperatures from spring through late-summer (USACE 1988) and warmer than natural during fall. Hansen and Crumrine's (1991) simulation of pre- versus post-project temperatures along the lower North Santiam River indicated that summer conditions were 6.8 to 16.9°F (3.8 to 9.7°C) cooler under post-project conditions, with the magnitude of effect varying among sites along the river and the years studied. Fall water temperatures were 6.1 to 12.8°F (3.4 to 7.1°C) warmer than pre-project conditions (Table 4 in Hansen and Crumrine 1991), also depending upon the study site and year. At the lower-most study site on the river, near Jefferson, daily temperatures appeared to be cooler than pre-project conditions for an average of 134 days per year and warmer for an average of 71 days per year (Table 5 in Hansen and Crumrine 1991). These effects of the USACE projects on the seasonal thermal regime could persist as far downstream as Jefferson.

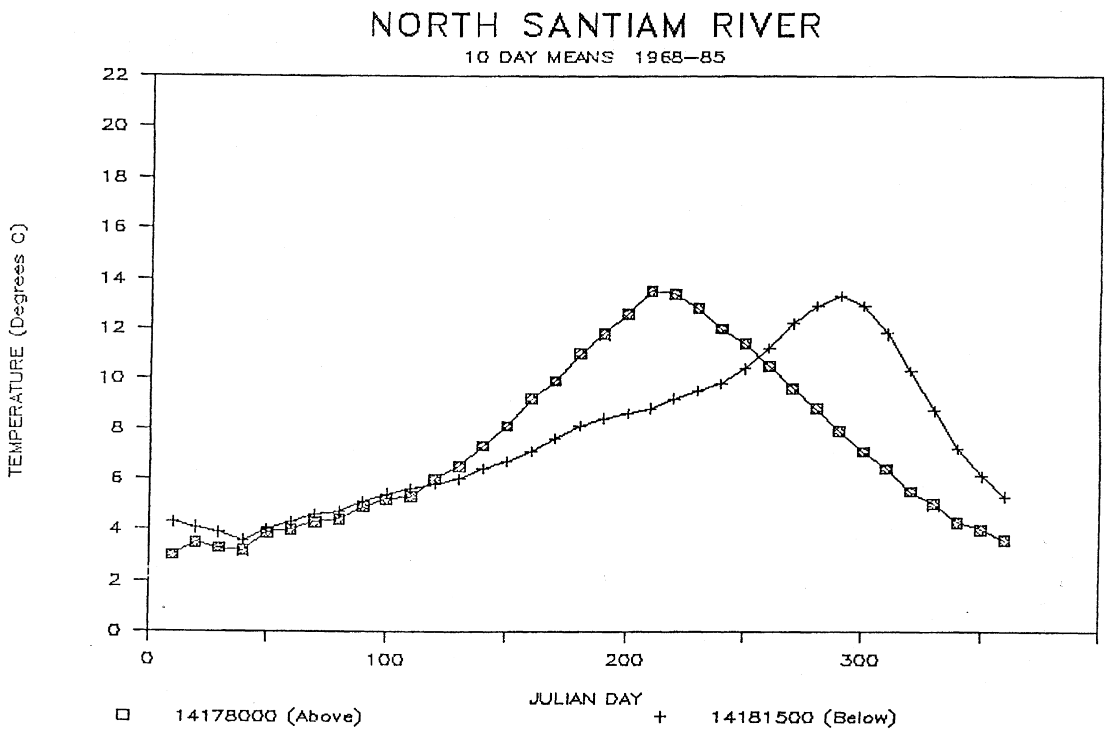


Figure 4.6-6 Water temperature changes caused in the North Santiam River by Detroit and Big Cliff reservoirs, 1968-1985. Julian Day 300 is October 28.

Water temperatures at the USGS gage below Big Cliff Dam have been cooler than pre-project temperatures during May through mid-September. Average daily water temperatures have often been below 52°F (11°C) during May through late-June since the Project was completed, cooler than natural conditions and cool enough to have delayed the upstream migration of adult Chinook salmon. The cooler temperatures during spring and early summer may also have delayed the emergence of steelhead fry, although neither of these effects has actually been reported in the North Santiam subbasin.

There is indirect evidence that warmer fall water temperatures have shortened the incubation time of Chinook salmon eggs below the USACE projects on the North Santiam, leading to early fry emergence. Within the Willamette Basin many young, naturally produced Chinook emigrate to downstream rearing areas soon after emergence in late winter and spring (ODFW 1990c). However, in 1989, well after completion of Detroit and Big Cliff dams, salmon fry were found to begin migrating past Stayton earlier than would otherwise be expected, as early as Thanksgiving and with an apparent peak in January (Cramer et al. 1996). Average daily water temperatures in the river below Big Cliff Dam can now exceed 43 to 55°F (6 to 13°C), the optimal range for egg incubation, from September through mid-November (see Figure 4.6-5), and thus may affect egg survival as well as the timing of fry emergence.

According to the ODEQ 2004/2006 Integrated Report (ODEQ 2006b), the maximum temperatures considered desirable for salmon and steelhead spawning (13^oC) and core cold-water habitats (16^oC) have been exceeded in the North Santiam River (at RM 0-38.8 and RM 0-45.3, respectively). Criteria for salmonid spawning, rearing and migration have been exceeded in the lower Santiam River (RM 0-12) due to loss of vegetation and shading as riparian woodlands were converted to agriculture (see Appendix E). High temperatures during Chinook spawning (September and October), can reduce the viability of gametes in holding adults. Temperatures in the mainstem Santiam River have also exceeded the 64°F (17.8°C) maximum temperature for summer uses, which include non-core rearing and adult and juvenile migration. As shown in Appendix E, Table E-2, exposure to temperatures above 64°F can reduce the growth of juvenile Chinook salmon and steelhead, impair smoltification, and increase the risk of disease. The maximum also has been exceeded in the lower 10 miles of the North Santiam River. All of these factors directly reduce juvenile outmigrant production and indirectly limit population abundance and productivity.

A TMDL for the Willamette Basin, approved for temperature in 2006 (ODEQ 2006a), identified target temperatures for releases below Big Cliff/Detroit Dam based on stream temperatures entering the reservoirs and representing temperature regimes under existing baseline conditions but as if the dams were not in place (Table 4.6-6).

Table 4.6-6 Monthly rolling average of the median of 7-day temperatures downstream of Big Cliff and Detroit dams and established ODEQ monthly target temperatures (ODEQ 2006a, Chapter 4). No data presented for December through March; allocations/targets were not determined necessary for November through March.

Month	Big Cliff/ Detroit Release Temperatures	ODEQ Target for Big Cliff/ Detroit Dam Releases
April	5.8	5.4
May	6.7	7.3
June	8.8	9.7
July	10.0	12.8
August	11.2	12.8
September	12.6	10.9
October	13..6	7.7
November	10.5	7.7

Water Temperature Control and Site-Specific TMDL Requirements

Operating projects to optimize temperature conditions downstream for fish is often inconsistent with TMDL temperature targets, even with a temperature control tower such as the one constructed at Cougar Dam. Experience in implementing water temperature control operations in the Sound Fork McKenzie River downstream of Cougar Dam to achieve more normative water temperatures suggest that special site-specific considerations may be required for such actions with respect to achieving ODEQ TMDLs. An operational requirement for successfully avoiding high temperature discharges in the fall(i.e., during spring Chinook salmon incubation) is to evacuate as much warm surface water as possible from the reservoir throughout the summer months while operating within the range of appropriate downstream temperature criteria for each month identified by ODFW. That is, it is necessary to balance the effect of warm water temperatures downstream of the dam across the spring, summer and fall periods to achieve the most appropriate overall biological effect. In the South Fork McKenzie River, the requirement resulted in summer water temperatures below Cougar Dam that were above the draft TMDLs identified by ODEQ during April through September (Figure 4.3-6) in order to provide more favorable temperatures during the critical incubation period in the fall. A focus on achieving the cooler TMDL temperature targets during summer would have adversely affected the temperature conditions achievable during the fall spawning and incubation period for spring Chinook because more warm surface water would have been retained in the reservoir over summer.

Emergency Shutdown & Experimental Temperature Control in 2007

Following a fire at the Detroit Dam powerhouse on June 19, 2007, the powerhouses of both the Detroit and Big Cliff projects were taken out of service, forcing water to be released through the projects' regulating outlets and spillways. Ad hoc efforts were made to manage these releases in a manner that provided beneficial downstream water temperatures. Immediately following the accident, all discharge at Detroit Dam occurred through the spillway which draws water from near the surface of the reservoir. In early July, Detroit Dam's regulating outlet, located deeper in the reservoir was opened to cool outflows to better protect incubating UWR steelhead downstream from Big Cliff Dam. In August, the USACE increased spillway flows, releasing warmer surface water (about 15 ºC) in an effort to reduce the volume of warm water in Detroit Lake in order to have cooler water in September for spawning UWR Chinook. To protect pre-emergent UWR steelhead fry, this operation took place after the emergence. When UWR Chinook spawning began in September, releases were managed toward cooler temperatures to more closely replicate natural fall temperatures that would allow for longer incubation period, thereby improving egg and fry survival. Shortly thereafter it was no longer possible to discharge water through the Detroit Dam spillway because the reservoir water surface elevation had fallen below the spillway crest. All discharge occurred through the project's regulating outlet located deep in the reservoir, resulting in colder water releases, until the autumnal turnover brought warmer water to the regulating outlet.

Throughout this period, plunging discharges from Detroit Dam into Big Cliff reservoir created elevated TDG conditions in the river. Efforts were made to determine if this TDG event adversely affected fish, particularly pre-emergent UWR steelhead fry. No adverse effects (i.e. dead fish) were detected and TDG conditions approached the regulatory standard (110 percent of saturation concentration) within several miles of the Big Cliff tailrace.

This ad hoc experiment demonstrated that managed operation of existing facilities at the Detroit and Big Cliff dams could reduce the thermal effects of the dams in the North Santiam River (Figure 4.6-6), although the balance obtained was inconsistent.

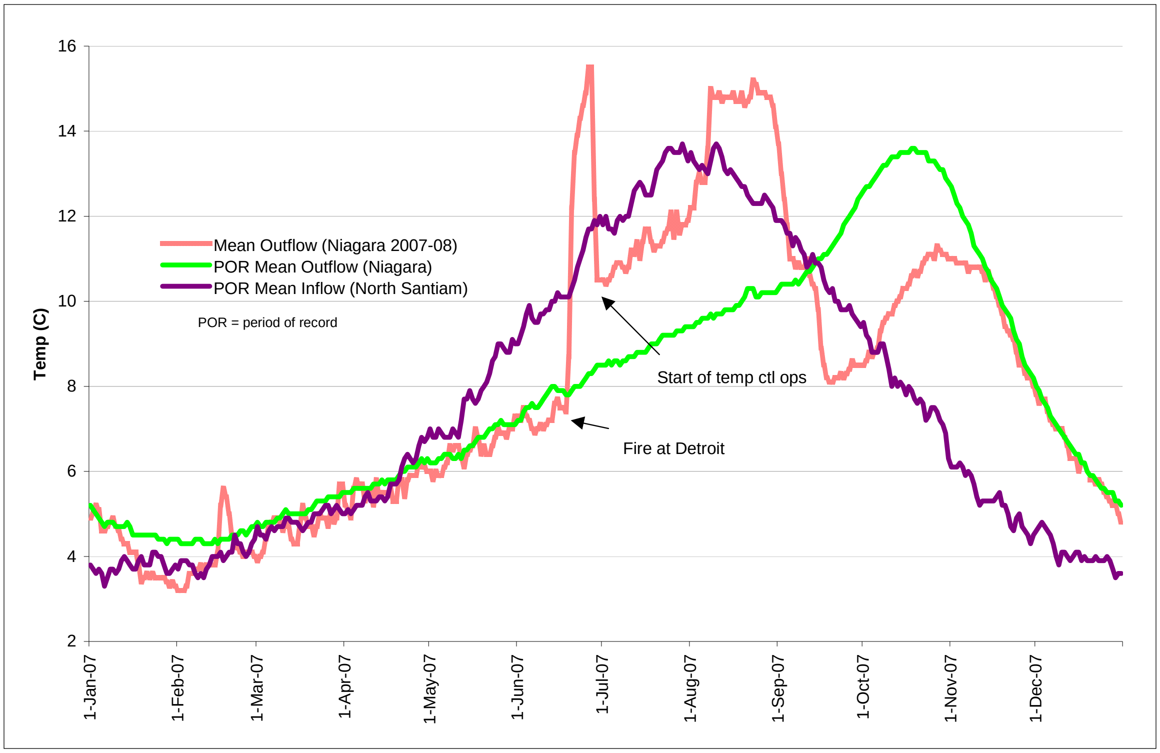


Figure 4.6-6 Mean, period-of-record (POR) calendar date water temperatures for the North Santiam River above and below the Detroit Project versus mean daily temperatures below the Project during 2007 (source: Scullion 2008). POR versus 2007 differences in below-Project (outflow) temperatures reflect the approximate thermal effect of operational changes in 2007.

4.6.3.3.2 Total Dissolved Gas

On March 8, 1972, Monk et al. (1975) measured total dissolved gas (TDG) levels of 117.9 and 129% of saturation at stations 211 and 950 feet downstream from Big Cliff Dam, respectively, and 120.2% at a site 2 miles downstream. Spill was 50% and 74% of total river flow at the first two stations (respectively) at the time of these measurements, which were taken at a depth of 1 meter. Some yolk sac fry may be exposed to TDG levels greater than 120% because ODFW releases unmarked spring Chinook salmon to spawn in the 3-mile reach between the Minto weir and Big Cliff Dam. The USACE has not assessed the risk of gas bubble trauma in this location, which depends on hydrostatic pressure at the depth of the redd and the presence of yolk sac fry during supersaturated conditions. Symptoms of gas bubble trauma have not been reported in juvenile nor adult anadromous salmonids in the North Santiam subbasin.

4.6.3.3.3 Nutrients

The ODEQ 2004/2006 Integrated Report database does not indicate that any streams below Big Cliff Dam are impaired due to excess nutrients. Operations at Detroit and Big Cliff dams that increase summer flows may have reduced nutrient loads in the mainstem North Santiam and Santiam Rivers.

4.6.3.3.4 Turbidity

Although high turbidity events have been reported in the North Santiam subbasin in recent years, there is no indication that turbidity has adversely affected the habitat requirements of anadromous salmonids. A February 1996 flood event in the North Santiam River[3] caused high turbidity that persisted for several months, with levels peaking near 140 Nephelometric Turbidity Units (NTU) (USGS 2002). This event halted operations for two weeks at the City of Salem's water treatment plant.[4] Subsequent high-flow events have caused persistent high turbidity, but effects of turbidity on local ecosystem function have not been assessed.

4.6.3.3.5 Toxics

The ODEQ 2004/2006 Integrated Report database does not indicate any exceedances of water quality criteria for toxics in the North Santiam subbasin.

4.6.3.4 Physical Habitat Characteristics

The general relationships between riparian conditions, large wood, sediment transport, channel complexity, and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E. Habitat characteristics of large wood, sediment transport, and channel complexity, and their status in the North Santiam subbasin under the environmental baseline are summarized in Table 4.6-8 and described in greater detail below.

Unfavorable human influences on the physical characteristics of habitat used now or historically by UWR Chinook and UWR steelhead tend to be least pronounced in those areas within the North Santiam subbasin that are dominated by federal lands. Consequently, much of the better habitat for these species now lies within currently inaccessible areas above Detroit Reservoir and in portions of the Little North Santiam watershed. This pattern reflects a stronger focus on aquatic conservation by federal land managers and a more diverse set of management objectives for the private lands found in lower portions of the subbasin.

Substrate

Substrates within many streams that are, or have been, used by the North Santiam's Chinook salmon and steelhead populations are influenced by the cumulative effects of various land-use activities and, within the lower North Santiam River, by the effects of Detroit and Big Cliff dams. Streambed substrates suitable for use by spawning Chinook salmon appear to be more abundant above than below these two dams (R2 Resource Consultants 2007). As suggested earlier, unfavorable influences on this habitat are thought be more pronounced in lower portions of the subbasin, below the dams.

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[3] During the February 1996 flood, 8 to 15 inches of precipitation fell in a 4-day period.

[4] The Salem water treatment plant uses a slow-sand filtration process that is unable to treat water with turbidity levels greater than 10 NTU. A pretreatment facility was built in 1997 to handle high turbidity conditions.

All coarse sediments transported from watersheds above Big Cliff Dam (60% of the North Santiam subbasin) are now trapped by Detroit or Big Cliff reservoirs and can no longer contribute to the creation or maintenance of high-quality habitats downstream in the lower North Santiam River. Assessments of these upper watersheds by the Forest Service (WNF DRD 1994, 1995, 1996, 1997) suggest that some of them, and particularly that of the Breitenbush River, may have once contributed disproportionately large quantities of coarse sediment to the river system. For example, approximately 2 million cubic yards of sediment had been trapped in Detroit Reservoir from the Breitenbush River alone within the first 40 years after dam construction (WNF DRD 1995).

Eliminating natural sediment delivery from areas above Detroit has made the lower river entirely reliant on its banks or floodplain, unstable areas along a narrow alluvial canyon immediately below Big Cliff Dam, the Little North Santiam River, and multiple small tributaries as sources of coarse sediment. The consequences, despite flow-related reductions in the lower river's transport capacity, have been a loss of finer textured gravel bars below Big Cliff Dam and a scouring of some areas near this dam down to bedrock with scattered boulders (WNF BRRD1994). This type of channel coarsening reduces the diversity of riverbed substrates and the availability of spawning habitat for anadromous salmonids.

Riverbed coarsening below dams in the Willamette system progresses at rates that vary locally (based in part on stream size, gradient, and alternate sources of sediment), but was assumed to travel downstream at 2,000 feet per year USACE (2000). If the coarsening of the lower North Santiam's riverbed has extended downstream at something close to this rate, its effect below Big Cliff may have extended downstream well into the alluvial canyon reach above Mehama that is heavily used by spawning salmon, and may be approaching the river's confluence with the Little North Santiam River. The degree to which the substrate coarsening process will be offset by sediment contributions from the Little North Santiam, or from multiple small foothill tributaries within the lower subbasin that have variable but often limited potential for sediment production (E&S 2002), is unclear.

The BLMS (1997) describes substrate conditions in streams within the Little North Santiam River watershed. Most surveyed reaches of streams in this watershed were rated fair to good for gravel quantity, and gravel quality was rated excellent in the mainstem of the Little North Santiam but variable in surveyed tributaries. Data from surveys conducted by ODFW on a limited number of the small streams flowing into the lower North Santiam River from private and state lands (http://oregonstate.edu/dept/ODFW/freshwater/inventory/nworgis.html) indicate variable substrate conditions, with segments of some streams exhibiting high levels of fine sediment in their beds.

Large Woody Debris

Large woody debris is frequently abundant within streams flowing through mature or old-growth forests on the Willamette National Forest, but timber harvest, road construction, and past stream clean-out operations have reduced the amount of wood found in streams draining some of the more intensively managed public watersheds above Detroit Reservoir (WNF DRD 1994, 1995, 1996, 1997). Reduced large wood levels can dramatically accelerate the transport of fine bed material and sediment out of small streams (Keller and MacDonald 1983; Beschta 1979) and degrade salmonid habitat. The Forest Service (WNF DRD 1994, 1995, 1996, and

1997) describes evidence that this has happened to streams above Detroit Reservoir that now have long, continuous riffles and little pool habitat or that have segments scoured to bedrock. Riparian areas along these altered streams are often in early- to mid-seral stages (WNF DRD 1995), and thus have limited near-term potential for contributing the large wood needed to restore damaged habitat. The Forest Service recognizes that this is an undesirable situation, and has begun restoration efforts that involve placing large woody debris back into wood-deficient stream segments above Detroit Reservoir.

All large wood that is transported from watersheds above Big Cliff Dam (60% of the North Santiam subbasin) now becomes trapped within Detroit and Big Cliff reservoirs, and is subsequently removed by the USACE. Such wood is thought to have historically exerted an important influence on habitat conditions within the lower river, particularly by contributing to channel complexity and the formation of pools, side channels, woody debris accumulations, and spawning habitats in unconfined, low gradient reaches (Abbe and Montgomery 1996). While there is little quantitative information on the magnitude of the effect this reduction in wood delivery had on aquatic habitat in the lower river, the volume of wood blocked by the dams suggests that the effect has likely been substantial. For example, an accumulation of large wood covering approximately 230 acres was removed from Detroit Reservoir following the 1964 flood (WNF DRD 1995).

Without wood from the upper subbasin, the lower North Santiam is now dependent on wood recruited from its banks, floodplain, or tributary watersheds. However, sources along the river's banks and floodplain have been diminished by land use (E&S 2002) and wood is captured less frequently from these areas due to flood control and bank stabilization projects. Prospects for wood recruitment from the lower river's tributaries have also been diminished. Surveyed streams within the Little North Santiam watershed typically contain less than desired levels of woody debris, and approximately half of the riparian areas evaluated within that watershed have low near-term potential for recruiting large wood to the stream network (BLMS 1998). Streams that have been evaluated within smaller watersheds tributary to the lower mainstem generally contain less than desirable levels of woody debris and have riparian areas with poor near-term wood recruitment potential (E&S 2002).

Channel Complexity, Off-Channel Habitat & Floodplain Connectivity

Reductions in channel-forming flows, decreased inputs of sediment and large wood, alteration or removal of riparian vegetation, revetments, and bank armoring, can impair the formation and maintenance of complex riverine and floodplain habitats important to salmonids (Appendix E, section E.5). Each of these disturbances has influenced channel conditions along the lower North Santiam River (E&S 2002) but the effects on salmonid habitats have not been quantified. Regardless, it is likely that the kinds of habitat simplification that have been documented elsewhere in the Willamette system (EA Engineering1991; Minear 1994; Benner and Sedell 1997) have occurred along the lower North Santiam.

The effects of Detroit and Big Cliff dams on channel processes downstream in the lower river are only partly responsible for channel simplification that has occurred in the lower North Santiam subbasin. Bank stabilization measures and agricultural development have also affected channel complexity and associated salmonid habitat. For example, as of 1989 the

USACE had installed revetments along 3.2 miles (5.1 km) of bank within the lower 20 miles of the North Santiam River an additional 7.6 miles (12.3 km) of revetments downstream of the South Santiam confluence (USACE 1989b). These types of structures constrain the river and its access to floodplain areas, limiting channel migration, the river's ability to capture woody debris from floodplain areas, and the formation of new side channels, pools, and other desirable salmonid habitats.

Analyses by Klingeman (1973) suggest that channel bed elevations in the lower-most reaches of the Santiam system may have lowered as a consequence of bank protection works, sand and gravel mining, or channel degradation extending upstream from the main Willamette. Such lowering would tend to diminish channel complexity and connections between river and floodplain. Log drives and removal of wood for navigation and flood control purposes, once common practices in Oregon (Sedell and Froggat 1984), may have contributed to this channel degradation by reducing the potential for sediment storage.

Riparian Reserves & Disturbance History

Riparian vegetation along streams in the North Santiam subbasin varies in response to natural differences in geology, precipitation, elevation, and disturbance regimes, and to man-caused factors including: timber harvesting, road building, and other land uses. At present, it is typically least disturbed in federally managed portions of the subbasin above the USACE dams or in the upper reaches of the Little North Santiam system, and most disturbed along lowland channels passing through areas affected by agricultural or rural-residential development.

Mature or old-growth forests remain along streams within significant portions of the extensive federal lands above the USACE dams and in the headwaters of the Little North Santiam River. However, timber harvest and near-stream road construction have removed or altered these forests along streams on other federal lands, both above the dams and in some areas (including portions of the Little North Santiam watershed) below the dams (WNF DRD 1994, 1995, 1996, 1997; BLMS 1997). All riparian areas on federal lands within the North Santiam subbasin are now being managed to maintain or recover high levels of natural function. Many of the riparian areas disturbed by timber harvest on these lands are already providing good stream shading (e.g., see BLMS 1997), but recovery of their natural potential to recruit large wood to stream channels and restructure salmonid habitats will require an extended period of recovery.

Riparian vegetation along the lower North Santiam River differs above and below Mehama, near the Little North Santiam confluence. Streamside forests along the reach of river from the site of Big Cliff Dam down to Mehama were once dominated by large conifers, but now include relatively few large conifers and consist of primarily small to moderate-sized trees (E&S 2002). Bottomland forests of black cottonwood, Oregon ash, and other native species that once dominated streamside and floodplain areas along the North Santiam River from Mehama to the mouth have been removed, altered, and fragmented by agricultural development, the construction of revetments, or other activities (E&S 2002). Riparian areas downriver from Mehama have now lost about 75% of their forest, and often include pastureland or other agriculturally-influenced vegetation like hedgerows or black hawthorn (E&S 2002). All of these changes in vegetation along the lower river have unfavorably affected natural processes that create and maintain high-quality salmonid habitats.

Many sections of riverbank downstream of Mehama have been diked or otherwise hardened by private landowners to limit flooding or bank erosion, but the exact locations and extent of these changes have not been quantified (E&S 2002). As noted earlier, the USACE has installed revetments above and below the South Santiam confluence. These dikes and revetments have displaced riparian vegetation, hinder vegetative re-growth, and inhibit interactions between the river and its floodplain.

Air photo interpretations suggest that riparian conditions on private lands bordering many of the small tributaries to the lower North Santiam are less than needed to maintain good salmonid habitat. Stream shade is low along significant segments of many of these streams, particularly within lowland areas, and the potential for wood recruitment from their riparian areas is poor (E&S 2002). Riparian vegetation along some lowland streams is likely insufficient to filter agricultural chemicals from surrounding farmland.

4.6.4 Hatchery Programs

Chinook

The native population of spring Chinook in the North Santiam has been affected by hatchery production since the first egg-take by the Oregon Fish Commission (OFC) in 1906 (Wallis 1963). Although over the past century most of the fish released into the North Santiam have come from locally-collected broodstock, stocks from outside the ESU have also been released. The existing program at Marion Forks Hatchery began in 1951 as mitigation for the loss of production upstream of Detroit and Big Cliff dams (construction completed in 1953). Hatchery fish have probably spawned in the wild every year since this hatchery program began. Genetic analyses of naturally-produced juveniles from the North Santiam River indicated that these fish were most closely related to other naturally- and hatchery-produced spring Chinook from the Upper Willamette River ESU (though they were still significantly different, $P>0.05$, Myers et al. 1998). Wild fish have probably been incorporated into the hatchery broodstock since the collections began at the Minto weir. However, until the 2001 return year, when hatchery fish could be distinguished from wild fish, the numbers of hatchery fish that spawned in the wild and of wild fish incorporated into the hatchery program were unknown. Now that all hatchery fish are externally marked, the current management strategy (NMFS 2000a) is to incorporate local adaptation into the broodstock by using some wild fish and to limit the percentage of hatchery fish spawning in the wild. NMFS' last biological opinion on the USACE hatchery program for UWR Chinook salmon expired in September 2003.

Steelhead

Native winter steelhead first were artificially propagated at the North Santiam Hatchery in 1930, when a record 2.8 million eggs (686 females at 4,170 eggs/female) were taken (Wallis 1963). Beginning in 1952, ODFW tried to compensate for the loss of wild production areas above Detroit and Big Cliff dams by releases of hatchery winter steelhead, but these attempts were generally unsuccessful (ODFW 1990a). The ODFW ended the winter steelhead hatchery program in the Santiam in 1998 due to concerns that residualized hatchery-origin steelhead[5] could interbreed and affect the genetic diversity of the native population, and the cost effectiveness of the program[6] (ODFW 2004a).

Although artificially propagated winter steelhead are no longer released into the North Santiam subbasin, annual releases of 161,000 hatchery-produced Skamania stock summer-run steelhead smolts continue to be made into the North Santiam system (ODFW 2004b). The purpose of this hatchery program is to augment the sport fishery while minimizing natural production (i.e., straying) by summer steelhead (NMFS 2000a).

Recent studies on the Clackamas River have shown that adult summer steelhead from hatchery programs can stray into and spawn in the natural spawning areas of wild winter steelhead, producing offspring that may be good competitors with juvenile winter steelhead even though such offspring may not themselves return as adult fish (Kostow et al. 2003). The consequence for a wild winter steelhead population of this type of juvenile competition with non-native summer steelhead can be reduced abundance and productivity (Kostow et al. 2003). Recent USACE-funded monitoring by ODFW has shown that adult summer steelhead returning from the releases of hatchery smolts into the North Santiam do in fact appear to be spawning in streams used by the North Santiam's winter steelhead (Table 4.6-7). Risks posed by the hatchery summer steelhead program are being further evaluated.

Stream	Winter steelhead redds	Summer steelhead* redds	Percent summer steelhead redds
Rock Cr.	49	19	28%
Mad Cr.	27	26	49%
Elkhorn Cr.	18	6	25%
Sinker Cr.	13	14	52%
All	107	65	38%

Table 4.6-7 Counts of winter and summer steelhead redds in monitored sections of streams in the lower North Santiam subbasin, 2003 (source: Firman et al. 2004).

*Redds counted prior to March 10 were identified as summer steelhead redds, though it was acknowledged, that pre-March 10 counts may have included redds from early spawning winter steelhead. Future genetic analyses of spawning adults and/or naturally produced juveniles from the subject streams will determine or confirm stock origin.

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[5] Cold water at the Marion Forks Hatchery precluded the accelerated growth typical of most hatchery programs and all smolts were released at age 2 instead of age 1. The protracted development period resulted in a high percentage of precocial males (up to 25%) which residualized in the system."

[6] Cost effectiveness was low, in part, because of the residualism mentioned above.

4.6.5 Fisheries

Chinook

UWR spring Chinook are primarily intercepted in the southeast Alaskan and north-central British Columbia ocean fisheries. They have been subject to high cumulative harvest rates in the past, but these have declined since 1975. Under the Pacific Salmon Treaty, ocean harvest rates on UWR Chinook have been in the range of 10 to 15% or less for more than a decade (PSC 2008), and given increasing emphasis on stock conservation it seems reasonable to assume that rates of less than 20% will continue into the future.

The average harvest rate on the North Santiam stock in the freshwater fishery (i.e., the mainstem Columbia, Willamette, and North Santiam rivers) was approximately 36% during 1970 through 2001, ranging as high as 52%. Under ODFW's Fisheries Management and Evaluation Plan (FMEP), freshwater anglers can retain only fin-clipped fish[7] and the fishery is managed so as not to exceed a handling mortality rate of 15% and an average fishery rate of 10 to 11% (ODFW 2001a).

NMFS expects the targeted freshwater fishery on fin-clipped fish to improve the population growth rate for the North Santiam subbasin population. The average annual harvest rate on wild fish ranged from 27.3 to 41.1% (overall average = 32.8%) during 1980 through 1995 (total harvest minus the Clackamas River sport fishery, from Table A-2 in ODFW 2001a). ODFW (2001a) estimates that the expanded marking program and targeted fishery will reduce the average annual harvest rate on naturally-spawned fish from 32.8% to less than 8%, resulting in an incremental increase in survival of 37%.

ODFW's FMEP for Upper Willamette spring Chinook requires freshwater fishery impacts to wild spring Chinook to be less than 15%. ODFW estimates that the impact to wild Upper Willamette spring Chinook was 12.4% for the North Santiam River population (ODFW 2007a).

Steelhead

A popular sport fishery targets the adult summer steelhead of hatchery origin that return to the North Santiam each year. These fish are marked with adipose fin-clips prior to release from the hatchery as smolts, and only those steelhead captured in the fishery that are missing this fin may be kept. All unmarked (assumed wild) steelhead captured by sport fisherman must be released unharmed. Incidental mortality of wild winter steelhead associated with this fishery is very low.

[7] ODFW now externally marks all hatchery-reared fish with an adipose fin clip, which distinguishes them from wild fish. Marking will allow fisheries to take hatchery fish while releasing wild fish and will allow removal of hatchery fish straying into wild production areas (ODFW 2001 = FMEP). The expanded hatchery fish-marking program was phased in beginning with the 1996 broods in the North Santiam and McKenzie subbasins (1997 broods in the South Santiam and Middle Fork subbasins) (ODFW 2001a).

4.6.6 Status of PCEs of Designated Critical Habitat and Factors Affecting those PCEs in the North Santiam Subbasin

NMFS determined that the following areas of the North Santiam subbasin contain or may contain Critical Habitat for UWR Chinook salmon or UWR steelhead (NMFS 2005d; maps are included in section 303 of this Opinion):

UWR Chinook (spring-run)

- Habitat that is of high or medium conservation value for these fish, and deemed important to their recovery, is present in all three watersheds occupied by UWR Chinook within the North Santiam subbasin (NMFS 2005g). These watersheds are all below Big Cliff Dam and contain 80.1 miles of PCEs for spawning/rearing and 45.3 miles of PCEs for rearing/migration of the species (NMFS 2005g). All three watersheds have been designated as Critical Habitat (NMFS 2005d), as described below:
  - The Middle North Santiam River and Little North Santiam River watersheds, both below Big Cliff Dam, have high conservation value and combine to provide 43.0 miles of spawning/rearing habitat and 1.8 miles of rearing/migration habitat (NMFS 2005g).
  - The Lower North Santiam River watershed has moderate conservation value and provides 37.15 miles of spawning/rearing habitat and 43.5 miles of rearing/migration habitat (NMFS 2005g).
- The three additional watersheds account for the unoccupied portion of the subbasin, above Big Cliff Dam. These include the Upper North Santiam, North Fork Breitenbush River, and Detroit Reservoir/Blowout Divide Creek watersheds. They have not been fully evaluated as potential critical habitat, but contain as much as 45.3 miles of habitat that was once used by UWR Chinook (NMFS 2005g). NMFS did not have enough information to warrant designation of these watersheds as Critical Habitat for UWR Chinook at the time the final rule was published, but they may be important to species recovery (NMFS 2005g).

UWR steelhead

- Habitat that is of high conservation value for UWR steelhead, and thus important to their recovery, is present in all three occupied watersheds within the North Santiam subbasin (NMFS 2005g). These watersheds contain 99.4 miles of PCEs for spawning/rearing, 37.3 miles of PCEs for rearing/migration, and 0.0 miles of migration/presence habitat (NMFS 2005g). All three watersheds have been designated as Critical Habitat (NMFS 2005d), as described below:
  - The Middle North Santiam watershed has high conservation value and 27.9 miles of spawning rearing habitat for UWR steelhead (NMFS 2005g).
  - The Little North Santiam River watershed has high conservation value for UWR steelhead and provides 27.9 miles of spawning/rearing habitat (NMFS 2005g).
  - The Lower North Santiam River watershed contains 43.6 miles of spawning/rearing habitat and 37.3 miles of rearing/migration habitat (NMFS 2005g).
- The three watersheds that account for all of the North Santiam system above Big Cliff Dam are unoccupied at present but did support UWR steelhead prior to dam construction. These

watersheds have not been fully evaluated as potential critical habitat for this species (NMFS 2005g). NMFS did not have enough information to warrant designation of these watersheds as Critical Habitat for UWR steelhead at the time the final rule was published, but they may be important to species conservation (NMFS 2005g).

Bank hardening measures associated with USACE flood control activities total 17,070 linear feet (3.23 miles) between Mile 12.5 and Mile 30 of the North Santiam River, with 10,309 feet (1.95 miles) on the right bank, and 6,761 (1.28 miles) on the left bank (USACE 2000). These measures adversely affect spawning/rearing areas designated as critical habitat.

NMFS (2005g) identified the key management activities that affect these PCEs. Key activities affecting the unoccupied, upper watersheds were not evaluated. Key activities affecting the Middle and Little North Santiam River watersheds below Big Cliff and Detroit dams include non-federal dams, agriculture, forestry, road building and maintenance, and mineral mining. In addition to the above factors, irrigation impoundment and withdrawals, sand and gravel mining, and urbanization are key factors affecting the Lower North Santiam watershed.

As described in previous sections, Big Cliff and Detroit dams block access to upstream spawning and rearing habitats, reduce downstream migrant survival, alter flows downstream, reduce or eliminate marine-derived nutrients from these upper watersheds, and limits the downstream transport of habitat building blocks. Detroit Dam also alters the formerly productive habitat above the dam by creating a 9.0 mile-long reservoir from about RM 61 to RM 70 (Mattson 1948). Big Cliff acts as a re-regulating dam for flows below Detroit Dam, and the Big Cliff Reservoir inundated an additional 2.8 miles of riverine habitat (RM 58.1-61). The Big Cliff/Detroit dam complex also negatively altered downstream water temperatures in North Santiam River. While the habitats upstream of these dams, unoccupied at the time the final rule was published, have not been designated as critical habitat, this habitat may be essential for conservation of UWR spring Chinook and UWR steelhead (NMFS 2005g).

Table 4.6-8 summarizes the condition of PCEs within the North Santiam River. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most cases, this is the result of the past operation and the continuing effects of the existence of the Projects or the effects of other human activities (e.g., development, agriculture, and logging). However, to the extent these conditions would be perpetuated by future operations or existence of the project, only the past impacts and project existence are included in the baseline.

Table 4.6-8 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the North Santiam River Subbasin under the environmental baseline .

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Indirect evidence that warmer fall temperatures have shortened the incubation and emergence timing of Chinook salmon fry	USACE operations (Detroit)
			The ODEQ 2004/2006 Integrated Report database indicates that maximum temperatures for spawning, incubation, and fry emergence have been exceeded in the lower North Santiam River (up to RM 26.5), and in the Santiam River below the mouth of the South Santiam	USACE operations (Detroit) Agriculture
			Maxima for core and non-core rearing and adult and juvenile migration have been exceeded in the mainstem Santiam River and in the North Santiam River up to RM 10	USACE operations Agriculture
			Maxima for core cold water habitat, spawning, rearing and migration also have been exceeded in streams above Detroit Reservoir (Marion Creek), and in tributaries to the lower reaches of the North Santiam (Chehulpum Creek, Bear Branch, and the Little North Santiam River, including Stout and Elkhorn creeks).	Timber harvest
			Average daily temperatures less than 52°F during May through late June, cool enough to have delayed the upstream migration of adult spring Chinook salmon	USACE operations (Detroit)

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	Although high turbidity events have been reported in the North Santiam subbasin in recent years, there is no indication that turbidity has adversely affected the habitat requirements of anadromous salmonids The ODEQ 2004/2006 Integrated Report database does not include any exceedances of water quality criteria for excess turbidity	N/A N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/Nutrients	The ODEQ 2004/2006 Integrated Report database does not include any exceedances of water quality criteria for toxics The ODEQ 2004/2006 Integrated Report database does not indicate that any streams are impaired due to excess nutrients Summer operations, which discharge flows higher than those flowing into the reservoir, may have improved water quality by diluting nutrient loads in the mainstem North Santiam and Santiam rivers	N/A N/A USACE operations (Detroit and Big Cliff)
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database indicates dissolved oxygen concentrations lower than the criterion for salmonid spawning and rearing (11 mg/L or 95% saturation) at RM 9.3 and RM 11.2 in the mainstem Santiam River (below the mouth of the South Santiam).	May be caused by same factors that cause high temperatures in this reach

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	Total dissolved gas (TDG) level of 129% saturation measured 950 feet below Big Cliff Dam; 120.2% measured 2 miles downstream	Regulating outlet spill at USACE's Detroit and Big Cliff dams
Freshwater migration corridors	Habitat access	Physical barriers	*Barriers below Big Cliff Dam* Reduced flows for upstream passage and juvenile entrainment into power and water supply canals in the lower subbasin During construction of Detroit and Big Cliff dams (early 1950s), a concrete weir (Minto Dam) was built about three miles downstream of the dams to replace the old hatchery rack. Minto Dam has blocked passage of all adult spring Chinook salmon and most winter steelhead since 1952 *Barriers above Detroit Reservoir* A hatchery rack near the mouth of the Breitenbush River (now under Detroit Reservoir) intercepted a large proportion of the adult spring Chinook salmon and winter steelhead runs from 1911 through 1941	SWCD City of Salem State hatchery operations Historical state hatchery operations (no longer a factor)

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat access	Physical barriers	*Big Cliff and Detroit projects as barriers* Both projects were built without fish passage facilities; populations are restricted to below Big Cliff Dam Preliminary screw trap studies indicate survival rates for juvenile spring Chinook of 51-60.5% at Detroit Dam and 69% at Big Cliff Dam; the combined survival rate for fish that pass both dams was 35-42% No estimate of reservoir survival available	USACE projects (Big Cliff/Detroit)
Freshwater migration corridors	Habitat access	Physical barriers	*Predation as a Barrier to Reservoir Migration* Cool water temperatures above Detroit Dam limit production of northern pikeminnows	USACE projects (Big Cliff/Detroit) – cold water in reservoir and dams as barrier to passage
Freshwater spawning sites	Habitat elements	Substrate	Substrate has coarsened downstream of Big Cliff Dam. River channel downstream of Big Cliff reservoir may be downcutting Channel downstream of Big Cliff Dam could lack spawning gravel Many areas scoured to bedrock Current sediment budget not creating and maintaining side channel and gravel bar habitat needed by anadromous salmonids	USACE reservoirs trap sediment from headwaters USACE operation of Detroit/Big Cliff reduces the magnitude and frequency of peak flows USACE and private revetments Gravel mining Historical log drives

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool Frequency and Quality	Reduced wood supply (USACE 2007a) has likely affected the frequency and quality of pools in the lower Santiam River below Detroit/Big Cliff.	Downstream LWD transport blocked by project dams; wood inputs from the lower subbasin are affected by riparian alterations, diking in the lower river, and flood control.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	*In the tributaries and upper mainstem North Santiam rivers* Large wood is lacking in most small tributaries; few meet the ODFW benchmarks Recruitment potential for large wood is low along most surveyed streams. *In the mainstem North Santiam and Santiam rivers* Reaches of the North Santiam River below Detroit and Big Cliff dams are deprived of large wood Inadequate recruitment of large wood from riparian areas along mainstem North Santiam and tributaries downstream from Big Cliff Dam. Lack of large wood-associated habitat for anadromous salmonids and invertebrates upon which they feed.	Timber harvesting Stream clean-out Fire suppression USACE removes large wood from reservoirs USACE removed snags in lower river for navigation Inadequate recruitment from riparian forests USACE and private revetments prevent recruitment of large wood from banks USACE operation of Detroit and Big Cliff dams reduces frequency of channel-forming flows needed to recruit large wood from banks

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	While no quantitative data are available, the North Santiam likely contains fewer off-channel habitats, simplified mainstem habitat, and few new gravel bars or channel surfaces	USACE operation of Detroit/Big Cliff reduces the magnitude and frequency of peak flows USACE and private revetments USACE removes large wood from reservoirs Gravel mining in lower river USACE traps sediment from 60% of upper subbasin in Detroit and Big Cliff reservoirs
Freshwater spawning sites Freshwater rearing	Channel conditions and dynamics	Width/depth ratio	Channel form in the lower watershed has been restricted by dikes and by loss of LWD; reservoir operations have restricted some channel forming processes (USACE 2000; E&S 2002).	Dikes; reduced LWD; Project reservoirs and reservoir operations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Streambanks do not support natural floodplain function in the lower river (USACE 2000; E&S 2002)	Diking; residential and agricultural land uses; timber harvest; roads; reservoir operations.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests	USACE operation of Detroit and Big Cliff reduces the magnitude and frequency of peak flows USACE and private revetments
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Road density and location	Roads enter streamside areas (E&S 2002)	Timber harvest; urban, agricultural, and industrial development.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/Hydrology)	Change in peak/base flow	Frequency of channel-forming flows not of sufficient magnitude to create and maintain channel complexity and provide nutrient, organic matter, and sediment inputs from floodplain areas Increased fall flows may allow spring Chinook to spawn in areas that will be dewatered during active flood control operations Winter and spring flow reductions may reduce rearing area and the survival of steelhead fry Increased summer flows may increase rearing area and the heat capacity of the stream Low summer flows in specific reaches (due to diversions) may reduce the juvenile rearing habitat area, block adult passage to upstream spawning areas, and decrease the heat capacity of the stream Flow fluctuations now occur at rates rapid enough to entrap and strand juvenile anadromous fish	Flood control operations at USACE's Detroit and Big Cliff dams reduce the magnitude and frequency of peak flows Fall releases from Detroit and Big Cliff dams to create storage space Winter flood control and late winter and spring refill operations at Detroit and Big Cliff reservoirs Flow augmentation from Detroit and Big Cliff dams to meet mainstem targets Summer diversions at SWCD's Stayton Complex and other diversions, including those served by USBR contracts Active flood control operations at USACE's Detroit and Big Cliff dams cause rapid flow reductions Rapid changes in diversion rates at the SWCD's Stayton Complex

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Disturbance history	Forests are dominated by early- to mid-successional stages, with few late-successional forests Disturbance regime is dominated by timber harvesting, which has increased sediment delivery to streams while decreasing large wood input Upper watershed is forested, but some is managed for timber production rather than ecosystem health Lower watershed contains extensive agricultural, urban, rural, and residential development Only 8% of lower watershed contains native Willamette Valley vegetation	Fire suppression Timber harvest Conversion to agricultural, urban, rural, and residential uses Flood control provided by USACE operation of Detroit and Big Cliff dams probably increased agricultural, urban, rural, and residential development within the floodplain.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	*Headwater forests riparian conditions* Most riparian areas in small tributaries are vegetated, but consist of alder or young coniferous riparian areas. Some drainages contain up to 33% mature riparian vegetation (e.g. Little North Fork), but others have less (e.g. Breitenbush). Many tributaries do not provide adequate shading or large wood recruitment. *Floodplain forest riparian conditions* Low large wood recruitment potential and poor shading because: The lower watershed contains only 25% of original extent of floodplain forest Many remaining patches of floodplain forest are interspersed with pastureland	Timber harvest Stream clean-out practices Clearing for agriculture or development USACE and private revetments USACE operation of Detroit and Big Cliff dams alters the hydrologic regime Private dikes Timber harvest

Section 4.7
Molalla Baseline

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4.7 MOLALLA BASELINE

The Molalla River subbasin (Figure 4.7-1) is the third largest of the six east-side and upper Willamette River subbasins (Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and Middle Fork Willamette) located above Willamette Falls in the Willamette River basin. These are the primary salmon and steelhead bearing subbasins.

The Molalla River flows out of the western Cascade Mountains to join the Willamette River north of the City of Canby. The Molalla watershed (including its largest tributary, the Pudding River) encompasses about 2,206 km^2 (852 $miles^2$; 545,114 acres) of land and supports a variety of land uses and fish and wildlife habitats. The Molalla River's headwaters drain the north, south, and western sides of the Table Rock Wilderness area managed by the Salem District of the U.S. Bureau of Land Management. The Pudding River's headwaters begin in the low elevation Waldo Hills east of Salem.

The Molalla River is approximately 49 miles long and enters the Willamette River at RM 36; the Pudding River is 62 miles long and enters the Molalla River at RM 0.75. The watershed has a maximum elevation of 2,600 feet and the hydrology is dominated by winter rainfall. The mainstem Pudding River has lower flows and higher water temperatures than the Molalla River drainage. The lower 20 miles of the Molalla River has a gradient of 0.2%. Almost the entire Pudding River channel is within the flat Willamette Valley floor, with a gradient of 0.04% for the first 50 miles.

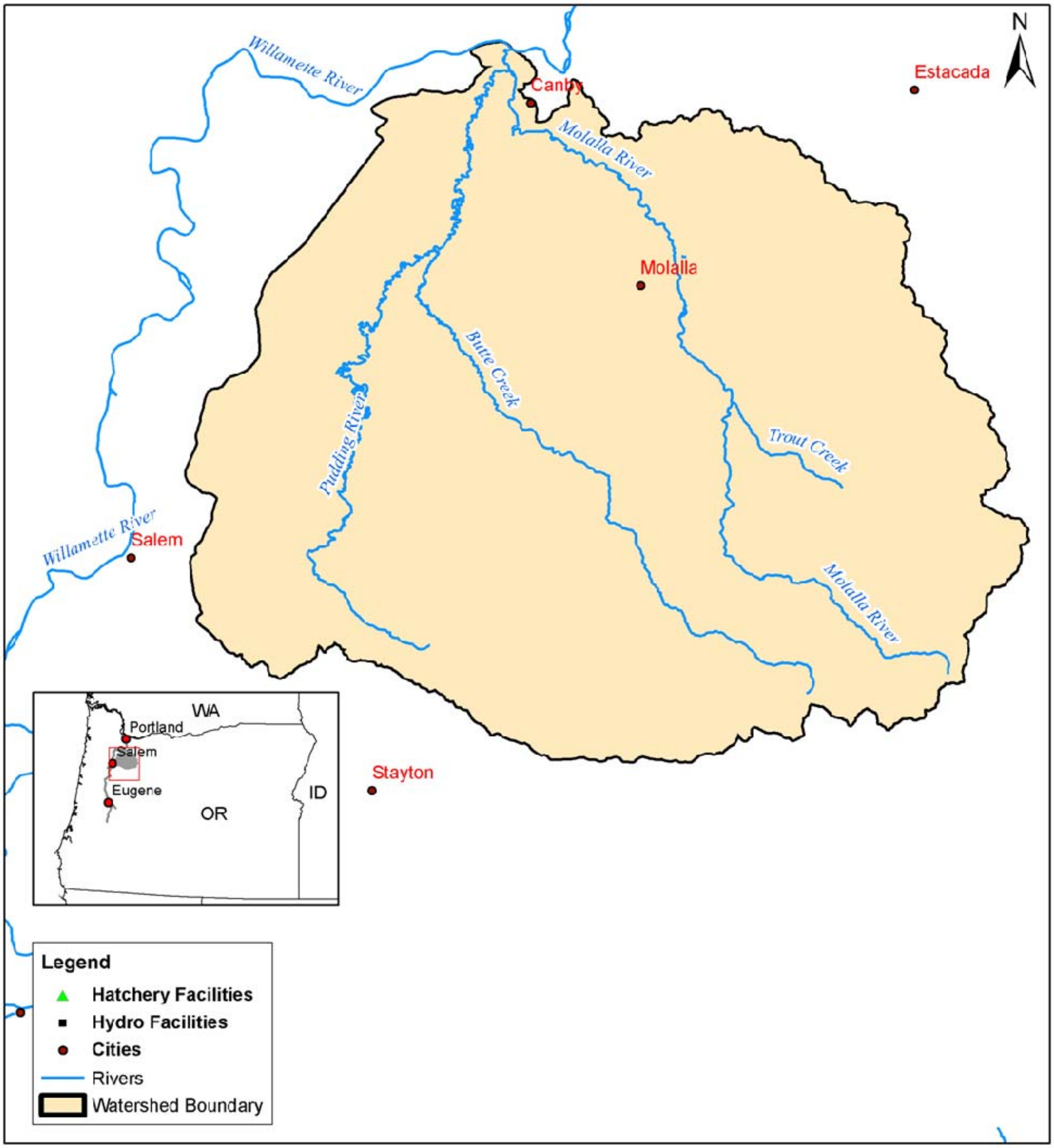

Figure 4.7-1 Map of the Molalla subbasin

The land cover or use is forest and shrubs (52%), agricultural (42%), and residential (Figure 4.7-2). Agriculture and rural residential development are the dominant land uses in the lower subbasin, with most of the development concentrated in the Pudding drainage.

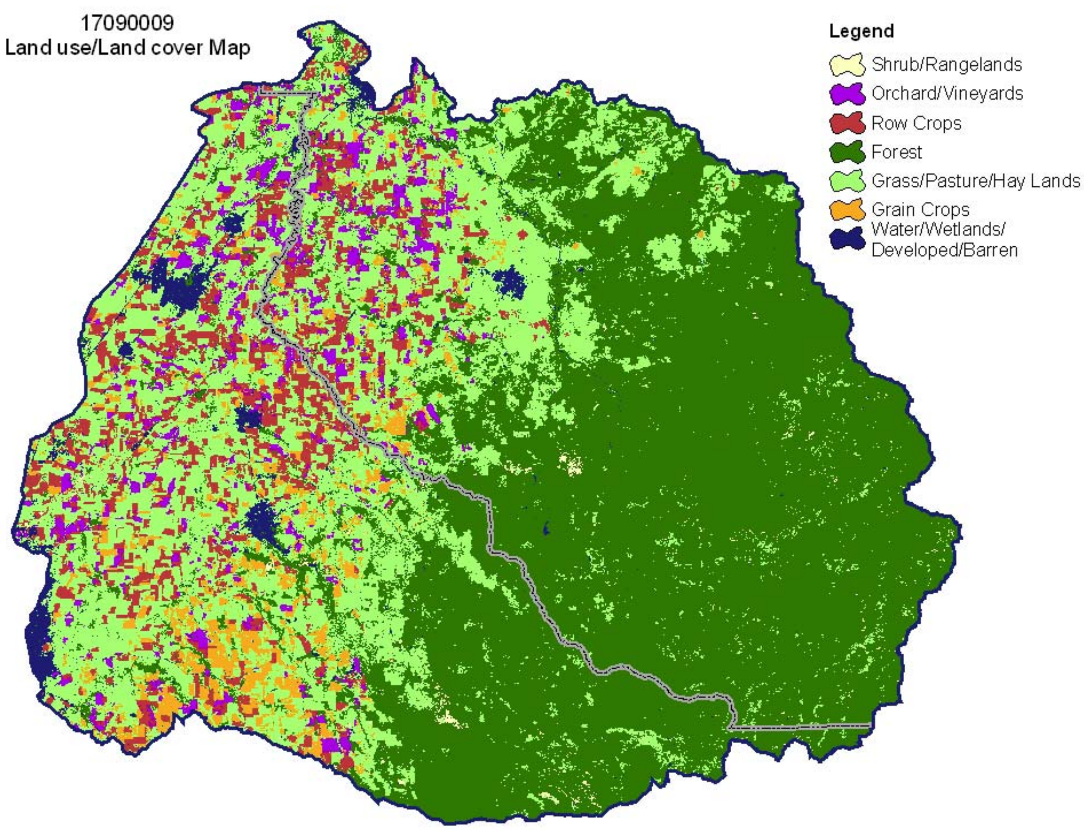

Figure 4.7.2 Land cover and use of the Molalla Subbasin (source: NRCS 2005b).

Most of the western half of the watershed is developed or in agricultural use, while the eastern half is primarily forested. Ninety percent of the watershed is in private ownership (Figure 4.7-3), with the balance in federal (9%) or state (1%) forestry management (WLCTRT 2004). There are numerous small communities and growing urban areas within the lower subbasin, including the cities of Canby, Silverton, and Molalla. The two largest population centers are the City of Canby at 12,000 people and the City of Molalla at 6,000 people. In addition, portions of the cities of Salem and Woodburn are within the lower subbasin. Forestland uses predominate in the upper Molalla River drainage and on tributaries to the Pudding River that drain the Cascade Range (e.g., Butte, Silver, and Abiqua creeks).

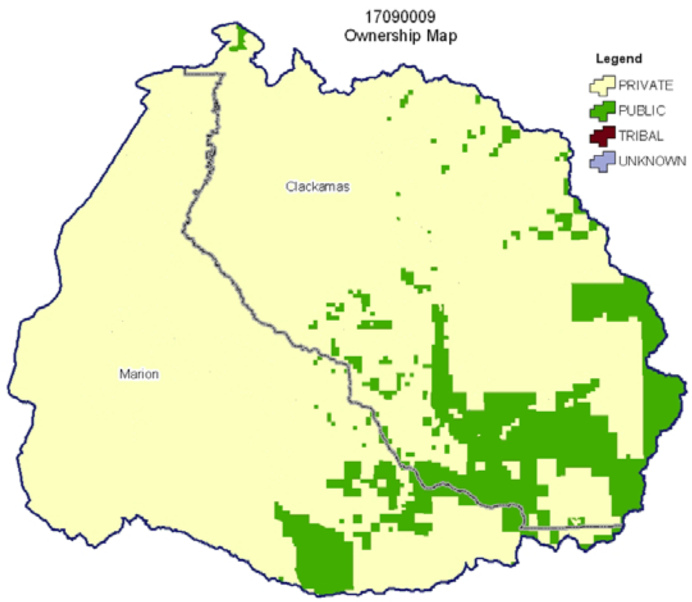

Figure 4.7-3 Land ownership patterns in the Molalla Subbasin (source: NRCS 2005b).

4.7.1 Historical Populations of Anadromous Salmonids

Both UWR Chinook salmon and UWR steelhead occur in the Molalla River subbasin.

There is very little information on the historical run size or distribution of the Molalla spring Chinook population, but it was estimated in the 1950s that there was sufficient habitat in the Molalla River Subbasin to accommodate at least 5,000 fish (Parkhurst et al.1950). By 1903, the abundance of spring Chinook salmon in the subbasin had already decreased dramatically (Myers et al. 2002). Surveys in 1940 and 1941 recorded 882 and 993 spawning spring Chinook salmon, respectively (Parkhurst et al.1950). Surveys in the 1940s observed 250 spring Chinook salmon in Abiqua Creek, a tributary to the Pudding River (Parkhurst et al. 1950). In 1947, Mattson (1948) estimated the run size to be 550.

There are no estimates of the historical winter steelhead production in the Molalla/Pudding Subbasin, although spawning areas are dispersed over approximately 110 miles of mainstem and tributary streams in the Molalla River watershed and 57 miles in the Pudding River watershed (WRI 2004). The historical population likely numbered in the thousands based on the quantity of available habitat.

4.7.2 Current Status

4.7.2.1 UWR Chinook Salmon

The UWR Chinook salmon population in the Molalla subbasin remains low in numbers compared to historical conditions. The current run of Chinook is almost entirely of hatchery origin, and consists of adult returns from hatchery outplants into the subbasin, adult strays from hatchery releases of juvenile fish into other tributaries of the Willamette River, and a few naturally produced offspring off hatchery-origin parents.

The historical population of spring Chinook in the Molalla and Pudding watersheds likely declined to the point where it was no longer viable during, or prior to, the 1960s (Cramer et al. 1996). Hatchery releases of spring Chinook have been made in the Molalla watershed since 1964 in an attempt to restore the population, although there is no evidence that this population has become self-sustaining (USACE 2000). There have been no recent observations of adult spring Chinook in the Pudding River watershed (WRI 2004).

A 2002 survey of 16.3 miles of stream in the Molalla found 52 redds. However, 93% of the carcasses recovered in the Molalla in 2002 were fin-clipped, indicating that they were of hatchery origin (Schroeder et al. 2002). Fin-clip recovery fractions for spring Chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners, so the true fraction is in excess of 93% and is likely to be near 100%. The natural population of Molalla spring Chinook is thought to be extirpated, or nearly so (USACE 2000). Hatchery releases to the Molalla River from 1964 to 1997 are shown in Table 4.7-1.

Table 4.7-1 Documented releases of hatchery-origin UWR Chinook into the Molalla subbasin (source: WRI 2004). [Note: data obtained from ODFW and included with submission of this draft could be used to update hatchery releases through 2007]

Watershed	Lifestage	Duration	Years	Source	Number
Molalla	Juveniles	1991	1	Clackamas FH	469,890
	Juveniles	1964-1997	8	McKenzie FH	2,892,050
	Juveniles	1981-1992	3	N Santiam FH	2,032,335
	Juveniles	1964-1965	2	Unknown	375,209
	Juveniles	1982-1999	12	Willamette FH	10,717,425
	Juveniles	1991	1	Oxbow FH	71,380
Pudding	Juveniles	1964	1	McKenzie FH	82,550
	Juveniles	1983-1985	3	Willamette FH	453,479
Total	**Juveniles**	---	---	----	**17,074,318**

4.7.2.2 UWR Steelhead

The UWR steelhead population in the Molalla River remains low in numbers compared to historical conditions. This run is of natural origin. There is currently no hatchery program for winter steelhead anywhere in the Willamette Basin, although there is a hatchery mitigation program for introduced (Skamania stock) summer steelhead. These hatchery fish have not been released directly into the Molalla River watershed since 1997, but adults originating from releases into other tributaries and returning to the Willamette River may stray into the Molalla River and spawn.

Current key spawning areas in the Molalla/Pudding Subbasin include the North Fork, Table Rock Fork, Milk Creek, and Copper Creek in the Molalla River watershed and Butte and Abiqua creeks in the Pudding River watershed. Chilcote (2007) estimated the number of winter steelhead spawners returning to the Molalla River from 1980 through 2005 based upon spawning redd counts and other related data (Figure 4.7-4).

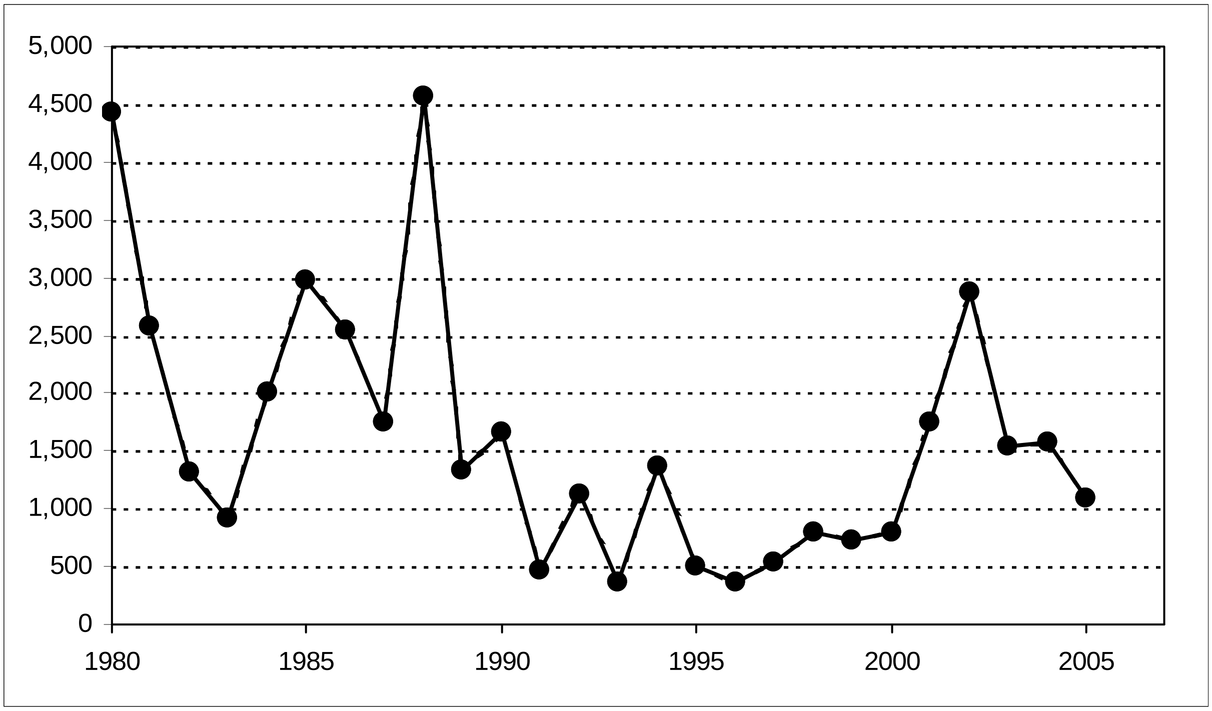

Figure 4.7-4 Estimated returns of native UWR Steelhead to the Molalla subbasin, 1980-2005 (source: Chilcote 2007).

Native (i.e., late-run) hatchery winter steelhead were released annually in the Molalla River for 21 years from 1957 through 1977, and in 1982 (Table 4.7-2). In more recent years (1970-1997), hatchery fish releases into the Molalla River were of non-native steelhead stocks and included many early-run winter steelhead from the lower Columbia River and summer steelhead from the Columbia River's Skamania stock.

Table 4.7-2 Winter and summer-run hatchery steelhead releases into the Molalla River, 1957-1997. Sources of summer-run fish are identified by an asterisk (*).

Watershed	Duration	Years	Source	From within ESU	From outside ESU
Molalla	1970-1996	10	Gnat Creek		497,922
	1984-1997	7	Skamania*		909,134
	1976-1993	17	Big Creek		908,516
	1970-1974	4	Alsea River		156,683
	1957-1977	6	Marion Forks/S. Santiam	270,912	
	1982	1	Marion Forks	23,492	
Total	---	---	---	294,404	2,472,255

4.7.2.3 Factors Limiting Productivity

The limiting factors and threats currently inhibiting the survival and recovery of UWR Chinook salmon and UWR steelhead in the Molalla River Subbasin, as identified in the Draft Willamette Chinook and Steelhead Recovery Plan (ODFW 2007b), are shown in Table 4.7-3. Even though the limiting factors and threats are broken into two groups (i.e., key and secondary), the secondary factors are important to address as well as the primary key factors.

Table 4.7-3 Key and Secondary Limiting Factors and Threats to Recovery of Molalla Spring Chinook and Winter Steelhead.

		Tributaries (Streams and Rivers within Population Area)									West Side Tributaries	Mainstem Willamette (above falls)		Estuary (below Bonneville and Willamette Falls)			Ocean
Threats	Species	Egg	Alevin	Fry	Summer Parr	Winter Parr	Smolt	Adult	Spawner	Kelt	Presmolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult	Adult
Harvest	Chinook																
	Steelhead																
Hatchery	Chinook								3					4a	4a		
	Steelhead														4a		
Hydropower/ Flood Control	Chinook													5a,5b,7h,10f 9j	5a,5b,7h,10f 9j		
	Steelhead														5a,5b,7h,10f 9j		
Landuse	Chinook	7a	7a	8a	9a 8a 10b	8a		8b 9c						5a 6e,8a,9a,9h,9i	5a 6e,8a,9a,9h,9i		
	Steelhead	7a	7a	9a 10b 2a	9a 10b 2a	8a 2a	2a	2a							5a 6e,8a,9a,9h,9i		
Introduced Species	Chinook																
	Steelhead																

Black cells indicated key concerns; Gray cells indicated secondary concerns.

Key and threats and limiting factors

3 Hatchery fish interbreeding with wild fish resulting in a risk of genetic introgression.

5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.

5b Increased microdetrital inputs due to reservoirs.

7h Impaired fine sediment recruitment due to dam blockage.

8a Impaired physical habitat from past and/or present land use practices.

8b Loss of holding pools from past and/or present land use practices resulting in increased prespawning mortality.

9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.

9c Elevated water temperatures from past and/or present land use practices leading to prespawning mortality.

10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary and threats and limiting factors

2a Impaired access to habitat due to road crossings and other land use related passage impediments on wadeable sized streams.

4a Competition with hatchery fish of all species.

6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.

7a Fine sediment in spawning gravel from past and/or present land use practices.

8a Impaired physical habitat from past and/or present land use practices.

- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10b Insufficient streamflows due to land use related water withdrawals resulting in impaired water quality and reduced habitat availability.

4.7.3 Environmental Conditions

4.7.3.1 Habitat Access

Impediments to fish passage can limit access to important areas for pre-spawner holding, for spawning, for refuge from high flow velocities, or for access to cool tributary streams when the mainstem Molalla and Pudding rivers or their tributaries warm during the summer months. Fish passage is restricted throughout the subbasin, in part by a number of small dams on Butte, Abiqua, and Silver creeks. Many of these dams are laddered for fish passage, but the effectiveness of the fish ladders is unknown (WRI 2004). Culverts on numerous small streams within the subbasin impede or block fish access to historical habitats, although the degree to which this limits population abundance has not been evaluated.

The fish ladder at Silverton's water diversion on Abiqua Creek has an inadequate entrance and is a partial fish passage barrier. There are unscreened diversions on the mainstem Molalla River near Shady Cove. Labish Ditch is an unscreened diversion that provides an inter-basin connection between Claggett Creek and the Little Pudding River.

The only active FERC hydroelectric power project in the Molalla Subbasin is a relatively small project on Woodcock Creek, a tributary to the Molalla River.

4.7.3.2 Water Quantity and Quality

Naturally low flows in the lower Pudding drainage are aggravated by water withdrawals, which contribute to increased summer water temperatures. High water temperatures are also aggravated by loss of riparian cover, reduced wetland areas, channel simplification, and increased impervious surfaces, particularly in the Pudding drainage. In general, summer water temperatures are lower in the forested portions of the upper subbasin tributaries of the Pudding River (i.e., Butte, Silver, and Abiqua creeks) and of the Molalla River.

Channelization of tributaries, modification of runoff patterns as a result of agriculture, impervious surfaces, and urban/residential development; and loss of storage capacity in floodplains and wetlands (particularly in the Pudding drainage) have accelerated runoff and increased peak flows. Nutrient and toxic runoff from agricultural and urban areas is an issue in the Pudding drainage. There has been extensive loss of wetlands throughout the subbasin. Loss of wetlands and floodplain habitats has affected water quality and quantity (i.e., storage and timing of peak and low flows).

The Molalla and Pudding rivers are listed by ODEQ as water quality impaired for temperature (11 segments), dissolved oxygen (2 segment), and bacteria (2 segments). In addition, one segment is listed for flow modification, and one segment each is listed for arsenic, iron, manganese, and DDT.

4.7.3.3 Physical Habitat Characteristics

The Molalla River is a gravel bed river characterized by multiple channels formed through active lateral stream migration and periodic avulsions. The stream has been substantially altered resulting from channelization, from placement of streambank revetments, and from loss of riparian habitat, including both forested and wetland areas (WRI 2004). Agriculture, urban, and rural development have encroached on local ecosystem function, separating the channel from its floodplain and limiting natural stream processes such as stream migration and formation of secondary and high water channels.

The USACE placed 5.07 miles of revetments along streambanks in the Molalla subbasin between 1938 and 1982, 2.49 miles of which are still maintained by the agency. Channels in the lower portions of the Molalla River, particularly near the city of Molalla (RM 20), and some tributaries have been simplified through placement of revetment and other actions. Revetments, roads, and other structures constrain sections of the lower Molalla River. Large portions of the lower Pudding River and sections of tributary streams have confined channels as a result of the placement of riprap and actions that restrict channel movement (WRI 2004). Revetments have simplified channels throughout the lower Pudding River and tributaries as a result of rural residential development and small community development near the stream channels.

Large wood is notably absent from large portions of the stream system, some of which was simplified by historical splash damming operations that sent artificial floods down channels to transport logs downstream toward mills. Historical removal of large wood from the rivers and their tributary streams, reduced transport and delivery of wood through channels, and changes in riparian vegetation have all interacted to reduce the quantity and distribution of large wood in the Molalla River Subbasin. Mature riparian forests make up a small proportion of the riparian areas in the lower subbasin (Hulse et al. 2002). Over time, a number of practices (such as splash dams and stream cleaning) removed large wood from the Molalla and Pudding rivers and tributary channels. While riparian areas in the forested upper subbasin have greater numbers of conifer trees than the lower subbasin does, historical wood removal from streams and riparian harvest has reduced large wood in the channels. Limited large wood in channels is particularly pronounced in the lower subbasin.

Reduced wood in the river and tributary channels has reduced the frequency and depth of pools, thus reducing habitat complexity important for adult fish (i.e., pre-spawner) holding and for juvenile rearing. Limited wood in tributary streams has reduced retention of spawning gravels.

Riparian areas along the river and tributaries, especially in the lower subbasin, are reduced in width, connectivity, and quality. There is some high-quality floodplain forest remaining along the lower Pudding River. Reed canary grass and Himalayan blackberry in the aquatic and riparian area limit the growth of native vegetation needed for natural habitat and channel formation processes. The loss of wetland, floodplain and off-channel habitats has affected the quantity and quality of adult holding areas and of juvenile rearing and high-flow refuge areas.

4.7.4 Hatchery Programs

ODFW has been releasing hatchery spring Chinook salmon in the Molalla River since 1964 (see Current Status, section 4.7.2). The current run of Chinook salmon is primarily of hatchery origin, comprised of hatchery outplants in the Molalla subbasin or strays originating from other Willamette Basin tributaries. Hatchery releases in the Molalla subbasin have been made in an attempt to restore a naturally self-sustaining population, although there is no evidence that this has been successful. Is it at all effective even if not successful or do all the fish die?

A 2002 survey of 16.3 miles of stream in the Molalla found 52 redds. 93% of the carcasses recovered were fin-clipped, indicating that they were of hatchery origin (Schroeder et al. 2002). Fin-clip recovery fractions for spring Chinook in the Willamette tend to underestimate the proportion of hatchery-origin spawners actually present, so the true fraction is in excess of 93% and is likely near 100%.

Hatchery threats exert key adverse effects on Molalla Chinook at the adult spawning life stage. Hatchery Chinook interbreeding with naturally produced Molalla Chinook presents a risk of continuing genetic introgression, preventing the development of a self-sustaining, naturally adapted, local population. Currently, about 100,000 Chinook smolts from South Santiam hatchery are released annually into the Molalla. These fish comprise most of the hatchery fish on the spawning grounds. Few redds have been observed from either naturally produced or hatchery spawners.

Native (i.e., late-run) hatchery winter steelhead were released annually in the Molalla subbasin for 21 years from 1957 through 1977, and finally in 1982, after which time the hatchery was closed. In more recent years (1970-1997), hatchery steelhead releases into the subbasin were of non-native stocks and included many early-run winter steelhead from the lower Columbia River and summer steelhead from the Columbia River's Skamania stock. Currently, no hatchery steelhead are released into the Molalla subbasin.

Summer steelhead present a risk to the abundance, productivity, spatial structure, and diversity of the local Molalla population of winter steelhead. While hatchery fish have not been released directly into the Molalla River subbasin since 1997, low densities of summer steelhead spawning have been observed in the mainstem Molalla River, in the North Fork Molalla River, and in Abiqua, Cougar and Lost creeks. Studies show adverse effects from non-native summer run steelhead on native winter run steelhead, especially when summer run fish spawn in the same areas as winter run fish (Kostow et al. 2003).

4.7.5 Fisheries

4.7.5.1 Spring Chinook

Harvest is a key threat at the adult life stage of the local Molalla River population of spring Chinook salmon, but only within the Molalla subbasin. Impacts to the Molalla spring Chinook population involve mortality caused by a catch and release fishery.

Relatively small numbers of naturally produced fish migrate from the Molalla subbasin each year. Most are progeny of naturally spawning hatchery fish released in the subbasin as juveniles. Sport fishing harvest within the Molalla River subbasin is restricted to possession of marked hatchery-origin fish. This is also true regarding harvest of spring Chinook salmon both outside of, and within, the Willamette River Basin. Harvest of naturally produced fish has, therefore, been curtailed to incidental catch beyond the identifiably marked hatchery fish. Given the small numbers of spring Chinook salmon naturally produced in the Molalla subbasin, even the otherwise incidental mortality associated with their capture and release may be a significant factor curtailing re-establishment of a naturally self-sustaining population and achievement of local population recovery.

4.7.5.2 Steelhead

To protect young winter steelhead (which often cannot be distinguished from cutthroat trout), ODFW has restricted trout fishing to catch-and-release. There is currently no direct harvest of naturally produced steelhead in the Molalla subbasin, although fin-marked (hatchery-origin) fish that stray into the subbasin may be kept.

4.7.6 Habitat Alteration (Status of PCEs of Designated Critical Habitat and Factors Affecting those PCEs in the Molalla River Subbasin)

NMFS determined that the following occupied areas of the Molalla River subbasin contain Critical Habitat for the UWR Chinook salmon and the UWR steelhead ESUs (NMFS 2005d; maps are included in section 3.3 of this Opinion):

- Mainstem Molalla River (for Chinook and steelhead)
- Gribble Creek (for Chinook and steelhead)
- Buckner Creek (for steelhead)
- Cedar Creek (for steelhead)
- Milk Creek (for Chinook and steelhead) and tributaries (for steelhead)
- Woodcock Creek (for steelhead)
- North Fork Molalla River (for Chinook and steelhead) and tributaries (for steelhead)
- Trout Creek (for steelhead)
- Pine Creek (for steelhead)
- Table Rock Fork Molalla River (for Chinook and steelhead) and tributaries (for steelhead)

- Copper Creek (for steelhead)
- Mainstem Pudding River (for Chinook and steelhead)
- Little Pudding River (for steelhead)
- Abiqua Creek and tributaries (for steelhead)
- Silver Creek (for steelhead)

NMFS (2005g) identified the key management activities that affect these streams and their PCEs: forestry, road building and maintenance, channel modifications, streambank armoring, agriculture, and urban/rural development. Indicators for temperature, bacteria, chemical contamination, streambank condition, stream channel condition, and riparian habitat condition are the basis for considering that these critical habitat features are currently at risk or not properly functioning (NMFS 2005h).

NMFS (2005d) identified the key management activities that affect these PCEs that include forestry, road building and maintenance, channel modifications, streambank armoring, agriculture, and urban/rural development. Indicators for temperature, bacteria, chemical contamination, streambank condition, stream channel condition, and riparian habitat condition are the basis for considering that these critical habitat features are currently at risk or not properly functioning (NMFS 2005h).

Table 4.7-4 summarizes the condition of PCEs within the Molalla and Pudding rivers. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most cases, this is primarily the result of human activities (e.g., development, agriculture, and logging).

Table 4.7-4 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for the Molalla River Watershed under the environmental baseline.

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Molalla River and Tributaries (except the Pudding River)* Fish passage is restricted throughout the subbasin. Numerous culverts throughout the subbasin present barriers to adult and juvenile refuge habitat, and to juvenile rearing habitat. There are unscreened diversions on the mainstem Molalla River near Shady Cove. The only active FERC hydroelectric power project in the Molalla Subbasin is a relatively small project on Woodcock Creek, a tributary to the Molalla River.	Road crossings and rural development Agricultural and rural development Privately owned dams
Freshwater migration corridors	Habitat Access	Physical Barriers	*Pudding River and Tributaries* Fish passage is restricted throughout the subbasin, in part by a number of small dams on Butte, Abiqua, and Silver creeks. Many of these dams are laddered for fish passage, but the effectiveness of the fish ladders is unknown. Numerous culverts throughout the subbasin present barriers to adult and juvenile refuge habitat, and to juvenile rearing habitat. The fish ladder at Silverton's water diversion on Abiqua Creek has an inadequate entrance and is a partial fish passage barrier. Labish Ditch is an unscreened diversion that provides an inter-basin connection between Claggett Creek and the Little Pudding River.	Private dams Road crossings and rural development Private dams Agriculture and rural development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base flow	Naturally low flows in the lower Pudding drainage are aggravated by water withdrawals Channelization of tributaries; modification of runoff patterns as a result of agriculture, impervious surfaces, and urban/residential development; and loss of storage capacity in floodplains and wetlands (particularly in the Pudding drainage) have accelerated runoff and increased peak flows. There has been extensive loss of wetlands throughout the subbasin. Loss of wetlands and floodplain habitats has affected water quality and quantity (i.e., storage and timing of peak and low flows).	Agricultural, urban, and rural development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Naturally low flows in the lower Pudding drainage are aggravated by water withdrawals, which contribute to increased summer water temperatures. High water temperatures are also aggravated by loss of riparian cover, reduced wetland areas, channel simplification, and increased impervious surfaces, particularly in the Pudding drainage. Summer water temperatures are lower in the forested portions of the upper subbasin tributaries of the Pudding River (i.e., Butte, Silver, and Abiqua creeks) and of the Molalla River. The ODEQ 2004/2006 Integrated Report database lists 11 stream segments as water quality limited due to high summer temperatures.	Agricultural, urban, and rural development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	The ODEQ 2004/2006 Integrated Report database does not report any streams as water quality limited due to turbidity.	N/A

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	The ODEQ 2004/2006 Integrated Report database indicates that 2 stream segments were water quality limited for occurrence of E. coli bacteria during summer low flow periods. One stream segment each was indicated as water quality limited for arsenic, iron, manganese, and DDT.	Agriculture, urban, and rural development
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database indicates that 2 stream segments were water quality limited for dissolved oxygen (ODEQ 2006b).	Agriculture, urban, and rural development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites	Habitat Elements	Substrate	The Molalla River is a gravel bed river characterized by multiple channels formed through active lateral stream migration and periodic avulsions. The stream has been substantially altered resulting from channelization, from placement of streambank revetments, and from loss of riparian habitat, including both forested and wetland areas. Limited wood in tributary streams has reduced retention of spawning gravels.	Agriculture, urban, and rural development
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Large wood is notably absent from the system which has been subject to historical splash damming. Historical removal of large wood from the rivers and their tributary streams, reduced transport of wood through channels, and changes in riparian vegetation have all interacted to reduce the quantity and distribution of large wood throughout the Molalla subbasin. Mature riparian forests make up a small proportion of the riparian areas in the lower subbasin. Splash dams and stream cleaning removed large wood from the Molalla and Pudding rivers and tributary channels. Riparian areas in the forested upper subbasin have greater numbers of conifer trees than the lower subbasin, but historical wood removal from these streams and riparian area has also reduced large wood in their channels. Limited large wood in channels is particularly pronounced in the lower subbasin.	Privately forest practices Historical splash dams and log drives Snag and removal of logs and log jams Removal of large wood by landowners and boaters for navigation and/or firewood Local development and agricultural development in the lower watershed resulting in riparian area depletion

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool Frequency and Quality	Development has encroached on local ecosystem function, separating the stream channel from its floodplain and limiting natural stream processes such as stream migration and formation of pools, secondary and high water channels. Reduced wood in the river and tributary channels has reduced the frequency and depth of pools, thus reducing habitat complexity.	Agriculture, urban, and rural development Removal of LWD, roads, channel scour, land uses such as timber harvest, and bank armoring in the lower river
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	USACE placed 26,759 feet of revetment along streambanks in the Molalla River drainage between 1938 and 1982. Channels in the lower portions of the Molalla River, particularly near the city of Molalla (RM 20), and some tributaries have been simplified through placement of revetment and other actions. Revetments, roads, and other structures constrain sections of the lower Molalla River, portions of the lower Pudding River, and sections of tributary streams. Revetments have simplified channels throughout the lower Pudding River and its tributaries.	USACE and private revetments Reduction in the magnitude and frequency of peak flows as a result of agricultural, urban, and rural development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Streambanks do not support natural floodplain function in the lower watershed.	USACE and private revetments Agricultural, urban, and rural development
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	The Molalla has been substantially altered, including both forested and wetland areas. There has been extensive loss of wetlands throughout the subbasin. Loss of wetlands and floodplain habitats has affected water quality and quantity (i.e., storage and timing of peak and low flows).	Channelization, placement of streambank revetments, and loss of riparian habitat Private forest practices USACE and private revetments Agricultural, urban, and rural development

PCE	Pathway	Indicator	Condition	Causative Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Disturbance history	The disturbance regime is dominated by timber harvesting in the upper watershed. Timber harvesting has increased sediment delivery to streams, but decreased large wood input, resulting in degraded aquatic habitat. Upper watershed is forested, but some is managed for timber production rather than ecosystem health. Most of the watershed (90%) is in private ownership. Lower watershed is predominantly agricultural, urban, and residential development.	Fire suppression Timber harvesting Conversion to agricultural, urban, and rural uses
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Riparian areas along the river and tributaries, especially in the lower subbasin, are reduced in width, connectivity, and quality. There is some high-quality floodplain forest remaining along the lower Pudding River. Reed canary grass and Himalayan blackberry in the aquatic and riparian areas limit the growth of native vegetation. Loss of wetland, floodplain and off-channel habitats has affected the quantity and quality of adult holding areas and of juvenile rearing and high-flow refuge areas.	Clearing for agriculture, urban, and rural development Timber harvest Stream clean-out practices USACE and private revetments Agricultural, urban, and rural development has altered the hydrologic regime

Section 4.8
Clackamas Baseline

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4.8 CLACKAMAS SUBBASIN

The Clackamas River enters the mainstem Willamette River at RM 25.1 (1.7 miles below Willamette Falls) after draining an area of 941 square miles, and is the fourth largest of the Willamette's tributaries. The Clackamas arises from the southern flank of Mt. Hood in the Cascade Mountains and has several major tributaries, including the Collawash River, Oak Grove Fork, and Fish Creek in the upper portion of its drainage network, and Eagle, Deep, and Clear creeks along the lower river (Figure 4.8-1). In all, 87% of the Clackamas subbasin is forestland and 69% of the subbasin is in public ownership (Figures 4.8-2).

The upper portion of the Clackamas system, above River Mill Dam and Estacada, is characterized by moderate to high-gradient stream reaches within mountainous terrain, while more gently sloped stream channels and topography dominate in the lower portion. The upper portion of the subbasin is heavily forested and primarily within the Mt. Hood National Forest. The lower portion, below Estacada, is more highly developed, and includes a variety of forest, agricultural, rural-residential, urban, and industrial land uses. The degree of landscape alteration within the subbasin increases with proximity to urban areas near the Willamette River. Industrial uses of the river's lowlands, particularly near the Willamette, include food processing, recycling of volatile organic compounds, feedlot and dairy farm operations, and rock and aggregate mining. Estacada is the largest city entirely within the subbasin, although the Portland suburbs of Gladstone, Johnson City, and Oregon City are located near the mouth.

The Portland General Electric Company (PGE) operates a multi-dam hydroelectric complex within the Clackamas subbasin, with the lower-most dam (River Mill) at RM 23.3 of the mainstem Clackamas not far below the city of Estacada. PGE's Clackamas River Hydroelectric Project also includes Faraday Diversion and North Fork dams on the mainstem Clackamas (at RM 28.4 and 30, respectively), and two additional dams on the Oak Grove Fork above areas naturally accessible to anadromous fish. Fish passage facilities that PGE has constructed and maintained at their dams on the mainstem Clackamas River provide anadromous fish access to all historically occupied streams above River Mill Dam.

4.8.1 Historical Populations of Anadromous Salmonids in the Clackamas Subbasin

The Clackamas subbasin once supported independent populations of wild anadromous salmonids from four ESA-listed evolutionary groups: LCR Chinook salmon, LCR coho salmon, LCR chum salmon, and LCR steelhead (Meyers et al. 2006). Historical information on each population is incomplete, but all of them were once substantially more abundant than at present. LCR Chinook native to the subbasin included a spring-run population and a fall-run, both of which were severely depleted by the early to mid-1900s. The distribution and abundance of the historical chum salmon population were never documented.

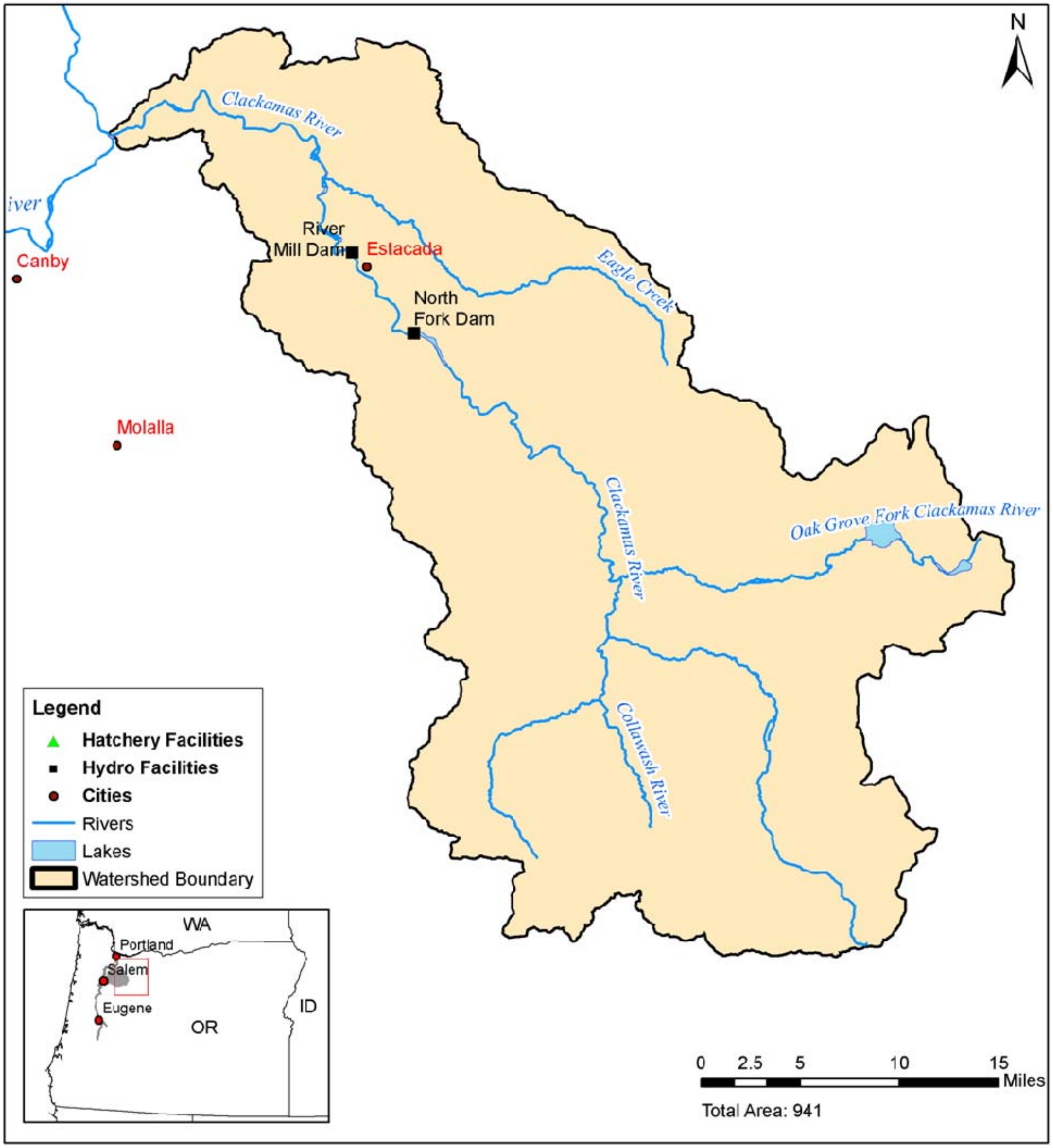
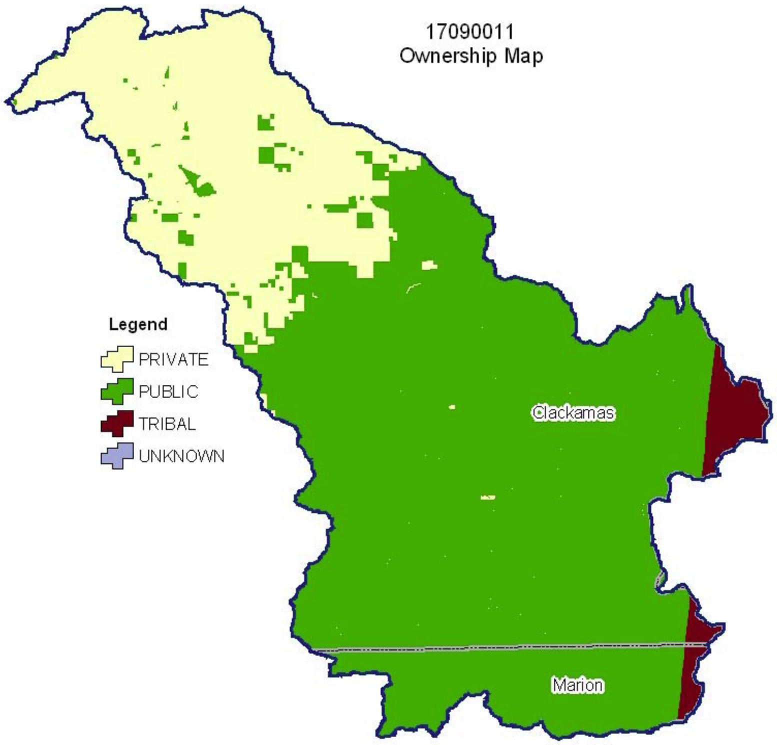
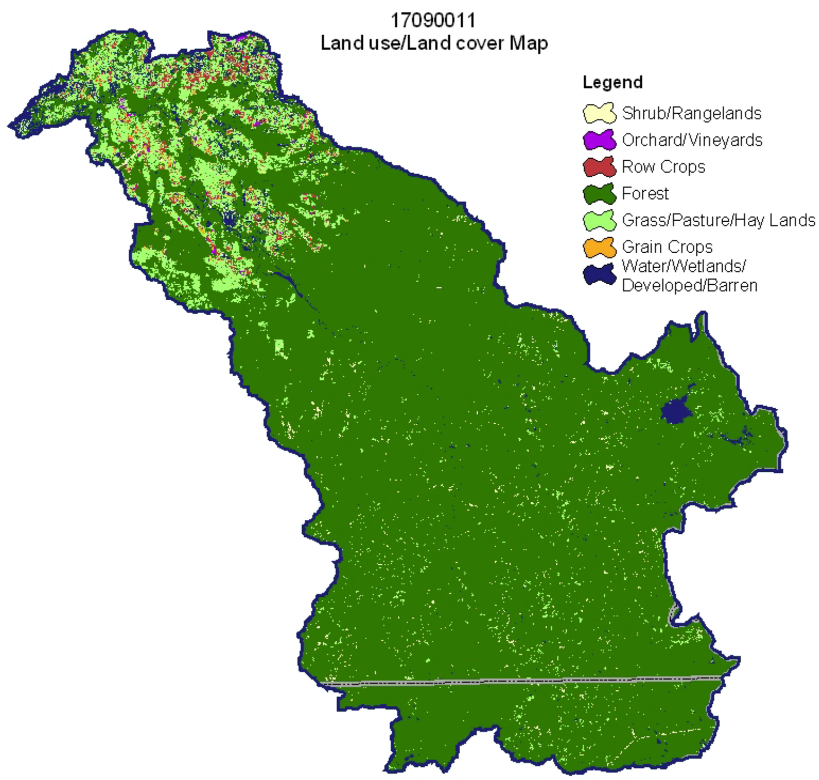


Figure 4.8-1 Map of the Clackamas subbasin





Figures 4.8-2 Patterns of land ownership (top) and land use/land cover (bottom) in the Clackamas subbasin (source: NRCS 2005b).

Spring-run Chinook Salmon

Approximately 8,000 adult spring Chinook were harvested from the lower Clackamas River in 1893 and about 12,000 were taken in 1894 for hatchery broodstock (Murtaugh et al. 1992). These numbers only partly reflect the historical productive capacity of the system, because many of the river's spring Chinook were also being harvested in fisheries on the lower Columbia River and portions of the annual runs were avoiding fisheries and hatchery operations to spawn naturally in the Clackamas subbasin. Most of the historical run is believed to have spawned in the Clackamas and its larger tributaries upstream of the current site of River Mill Dam, though Eagle Creek was also an important spawning stream (McIntosh et al. 1995). The majority of historical spring Chinook salmon production probably came from the mainstem Clackamas and Collawash rivers (Willis et al. 1960).

By the time early hydroelectric dams were constructed on the Clackamas, first Faraday Dam in 1904, then River Mill Dam in 1911, fishermen had already noticed severe declines in the subbasin's run of spring Chinook (SPC&A 2001). These declines had likely been caused by over-fishing, early habitat damage in the lower Clackamas subbasin, and broodstock collections at temporary weirs that were operated by ineffective hatchery programs. The dams worsened the situation for the run by further impeding fish migrations to spawning areas in the upper subbasin and providing fish culturists an opportunity to use fish ladders to collect much of what remained of the natural salmon population for hatchery broodstock. For several years beginning in 1911, all spring Chinook salmon that reached River Mill Dam and entered its ladder were used as hatchery broodstock (Taylor 1999). From 1917-1939, fish access to areas above Faraday was blocked after that dam's ladder was destroyed by floodwaters (Taylor 1999).

Upstream passage was restored at the dams on the mainstem Clackamas in 1939, allowing anadromous salmonids to recolonize the upper subbasin (SPC&A 2001). However, the spring Chinook run that became established above the dams after passage was improved was derived from a population in the lower subbasin strongly influenced by hatchery programs that frequently used broodstock from the UWR Chinook populations found above Willamette Falls. The spring Chinook population now found throughout the Clackamas subbasin is more closely related genetically to UWR Chinook than to the LCR Chinook presumed to have once been present (Meyers et al. 2006).

Fall-run Chinook Salmon

A fall-run of LCR Chinook salmon was abundant historically in the Clackamas subbasin and apparently spawned in the mainstem river up to a point above the current site of North Fork Dam (Fulton 1968). However, this native population was extirpated during the 1930s as a consequence of severe water pollution problems in the mainstem Willamette River below Willamette Falls (Parkhurst et al. 1950). Dimick and Merryfield (1945) reported that the native run had entered the Willamette in September and October and spawned soon after entering the Clackamas River. In 1902, for example, approximately 10 million fall Chinook salmon eggs were collected between 22 September and 08 November at a hatchery weir constructed on the lower Clackamas, with peak collections on 15 October (Titcomb 1904). Assuming fecundities reported by Titcomb (~4,380 eggs/female) and that about half the 1902 run was female, returns of fall Chinook to the lower Clackamas River weir site exceeded 4,500 fish in that year.

Fall Chinook were actively reintroduced into the Clackamas subbasin after the severe water pollution problems in the lower Willamette were addressed by wastewater treatment and baseflow augmentation from the USACE's Willamette Project. Hatchery stocks derived from fall-run populations in other tributaries to the lower Columbia River were released into the subbasin from 1952 to 1981 in an effort to reestablish a natural run (Meyers et al. 2006). Returns of fall Chinook to the Clackamas declined to low levels after the hatchery releases were terminated (McElhany et al. 2007).

LCR Coho Salmon

Abernethy (1886) reported that the coho salmon run in the Clackamas River lasted from mid-September to mid-December, and that it was about equal to the Chinook salmon run. Barin (1886) observed that coho in the system began spawning in about mid-January. Coho salmon passage at North Fork Dam historically was unimodal with a peak in mid-November, but run timing at the dam is now bimodal with peaks in September and January (Cramer and Cramer 1994). Of the two runs, the late run is thought to be native, while the early run is considered to be the result of hatchery introductions (Olsen et al.1992).

Recent EDT-based analyses of the Clackamas subbasin suggest a historic capacity to produce a run of about 15,000 adult coho under average ocean survival conditions (WRI 2004). A compilation of data on the subbasin's coho from the late 1950s forward (Chilcote 2007) suggests that the subbasin produced many more wild coho than this during multiple years when ocean survival conditions were high.

CR Chum Salmon

Barin (1886) reported that a native run of dog (chum) salmon appeared in the Clackamas River by November and spawned soon afterward. However, by 1944 these fish were not found during biological surveys (Dimick and Merryfield 1945) and had probably been extirpated by the same water-quality problems in the lower Willamette that had eliminated the Clackamas's native run of fall Chinook. No data are available on the historical spawning distribution or abundance of these chum salmon.

LCR Steelhead

The Clackamas subbasin's native run of winter steelhead represents one of 23 historical, demographically independent populations of LCR Steelhead (Myers et al. 2006). Although information on the historical abundance of the Clackamas population are incomplete, they indicate that steelhead runs in the subbasin were once much larger than under current conditions. Recent EDT-based analyses of the Clackamas subbasin suggest a historic capacity to produce a run of about 10,000 adult steelhead under average ocean survival conditions (WRI 2004). Because of their association with swifter flowing habitats, steelhead would have been distributed throughout much of the subbasin, and present even in areas that were not used by Chinook or coho salmon (SPC&A 2001).

4.8.2 Current status of ESA-Listed Salmon and Steelhead in the Subbasin

4.8.2.1 UWR (spring-run) Chinook Salmon

Population Viability

The Clackamas population of UWR Chinook is considered to be at a relatively low risk of extinction based on an assessment of its abundance, productivity, spatial structure, and diversity (McElhany et al. 2007). Contributors to extinction risks that the Clackamas population faces within the subbasin include:

- reductions in diversity and productivity caused by a combination of genetic introgression from non-local hatchery stocks and a 22+ year period when the natural population was excluded from its natural habitats in the upper Clackamas subbasin (ODFW 2007b);
- fish passage injury, mortality, and delay at the Clackamas River Hydroelectric Project;
- diminished habitat quality in the lower Clackamas subbasin; and
- potentially catastrophic events such as landslides or disease outbreaks caused by hatchery operations (WLCTRT 2003).

Abundance & Productivity

The natural-origin UWR Chinook in the Clackamas subbasin constitute one of only two populations out of seven (the McKenzie is the other) that appear abundant and productive enough not to be at high near-term risk of extinction (McElhany et al. 2007). Estimates of the annual abundance of wild Clackamas spring Chinook since 1958 (Chilcote 2007, Figure 4.8-3) suggest a long-term (1958-2005) geometric mean of 902 spawners and a recent (1990-2005) geometric mean of 1,656 spawners (McElhany et al. 2007). These fish appear to experience lower rates of pre-spawn mortality than do the populations of UWR Chinook that lack access to habitats above the dams on other Willamette River tributaries, with annual rates of loss above North Fork Dam estimated at 9-26% (mean = 19%) from 2003-2005 (Schroeder et al. 2005).

Although stray hatchery-origin fish with fin clips are sorted at a fish trap below Faraday Dam to prevent their entry into the upper Clackamas subbasin, ineffective marking (regenerated adipose fins that were originally clipped) by the large hatchery program in the lower subbasin allows sizeable numbers of hatchery-origin spawners to be passed upstream. Schroeder et al. (2005) found an average of 26% hatchery-origin fish among spring Chinook carcasses recovered from upper basin spawning grounds during 2003 and 2004. The proportion of hatchery-origin fish found decreased with increasing distance upstream from North Fork Dam (Schroeder et al. 2005).

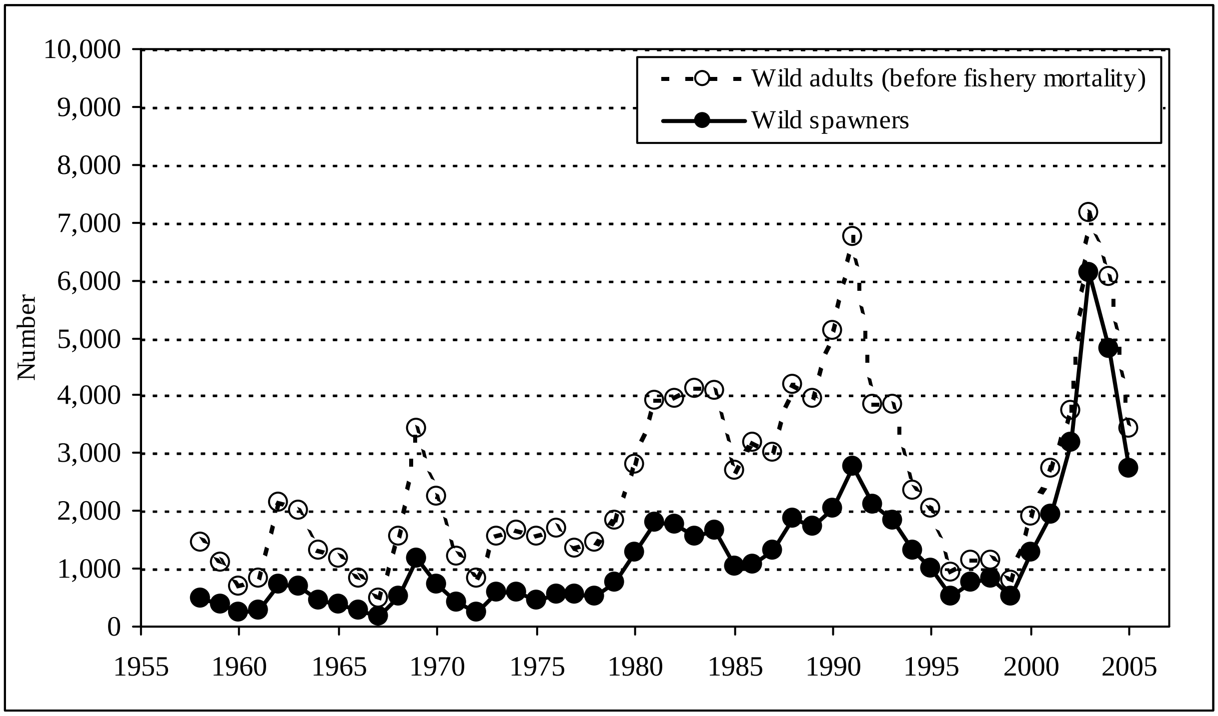


Figure 4.8-3 Estimated annual abundance of natural-origin ("wild") Clackamas spring Chinook, 1958-2007 (data source: Chilcote 2007).

Spatial Structure

The spatial structure of the Clackamas' spring Chinook population poses a low risk of extinction. Spring Chinook in the subbasin have access to nearly all of the areas that were available to the historical population (ODFW 2007b). A portion of the historical rearing habitat for these fish has been inundated by the construction of PGE's three dams on the mainstem Clackamas, but rearing conditions within the reservoirs behind these dams is known to be well used by juvenile Chinook (SPC&A 2001). Mainstem habitats in the lower subbasin have been degraded, but are believed to have been secondary to upper basin habitats in importance to the historical population (ODFW 2007b).

Diversity

Clackamas spring Chinook have likely experienced losses of diversity characteristic of a population at moderate risk of extinction (McElhany et al. 2007). As noted earlier, access to the productive spring Chinook habitat in the upper subbasin was eliminated for an extended period of time and the population has been genetically influenced by hatchery programs based on out-of-subbasin broodstocks. Life history traits of the current population, particularly the time of spawning, differ from those described for the historical population (ODFW 2007b) and may be a poorer match to the habitat conditions found in the subbasin (SPC&A 2001).

4.8.2.2 LCR (fall-run) Chinook Salmon

The fall run of Chinook salmon in the Clackamas subbasin has declined in the decades since hatchery supplementation ended, is quite small, and is not a primary focus of monitoring efforts.

Within the Clackamas subbasin, these fish are largely confined to the mainstem below River Mill Dam and the lower reaches of the major tributaries (Deep, Clear and Eagle creeks) to the lower river (personal communication, Doug Cramer, PGE). Available data on the population's abundance are of uncertain reliability, and the population should be considered "extirpated or nearly so" (McElhany et al. 2007). The HSRG (2008) has estimated that average annual returns of natural-origin LCR (fall) Chinook to the Clackamas subbasin (~50 adults) are exceeded by the average number of stray hatchery-origin fish entering the subbasin from programs elsewhere in the Lower Columbia region (~70 adults).

4.8.2.3 LCR Coho Salmon

Population Viability

Natural-origin coho in the Clackamas subbasin appear to constitute one of only two LCR coho salmon populations in Oregon that have maintained significant natural production and genetic continuity with their historical predecessors. Based on an assessment of the Clackamas population's abundance, productivity, spatial structure, and diversity, McElhany et al. (2007) classified it as having a low to moderate risk of extinction. This makes the Clackamas population the only one that might be considered viable within the entire LCR Coho ESU (McElhany et al. 2007). Contributors to extinction risks the population faces within the Clackamas subbasin include:

- habitat degradation in the lower subbasin (WRI 2004);
- reductions in diversity and productivity that may remain as legacies of intense commercial fisheries that have only recently become managed with a strong emphasis on conserving natural coho populations (Cramer and Cramer 1994; McElhany et al. 2007);
- imperfect fish passage at the Clackamas River Hydroelectric Project that is in the process of being improved; and
- high proportions of stray hatchery-origin coho in natural spawning areas within the lower subbasin (WLCTRT 2003).

Abundance & Productivity

In their viability assessment of Clackamas coho, McElhany et al. (2007) rated the natural-origin population's abundance and productivity as reflecting a low extinction risk. Data compiled by Chilcote (2007) show that adult abundance dropped to very low levels during multiple years in the 1990s but has since rebounded to somewhat higher levels (Figure 4.8-4).

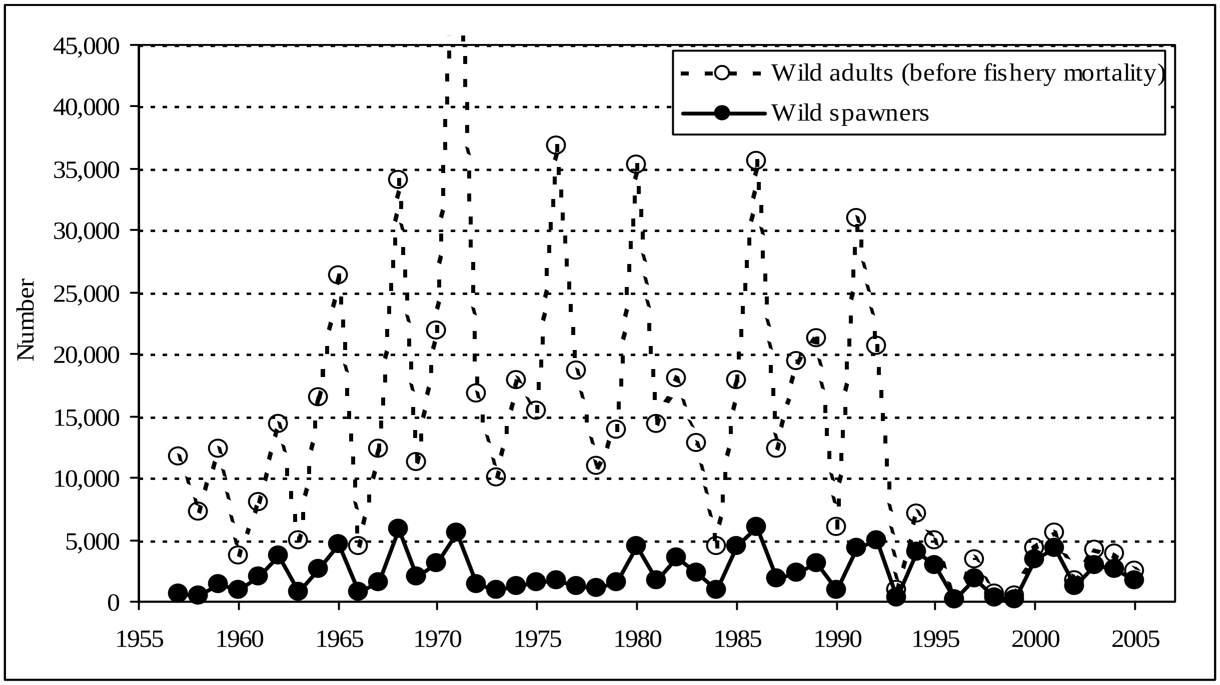


Figure 4.8-4 Estimated abundance of natural-origin ("wild") late-run Clackamas coho, 1958-2005 (data source: Chilcote 2007).

Spatial Structure

The spatial structure of the Clackamas coho population, which expanded after fish passage to the upper subbasin was restored in 1939, was rated by McElhany et al. (2007) as posing a low risk of extinction. The historical Clackamas coho population had access to an estimated 385 km of habitat (ODFW 2005b). Virtually all (97%) of this habitat is now accessible to these fish (ODFW 2005b), with limited losses of accessibility in higher order tributary streams, primarily due to watershed development in the lower subbasin (McElhany et al. 2007).

Diversity

McElhany et al. (2007) rated the diversity of the LCR Coho in the Clackamas subbasin as that of a salmonid population facing low to moderate risk of extinction, with concerns including changes in life history, recent abundance bottlenecks (see Figure 4.8-4), and high proportions of hatchery-origin fish using spawning areas in the lower subbasin. Cramer and Cramer (1994) observed that the wild population had experienced a shift to later adult return and spawn timing, hypothesizing that this caused a reduction in spawning distribution, later fry emergence, a shortened growing season, and changes in juvenile migration. They attributed the shift to severely high adult harvest rates. McElhany et al. (2007) suggest that these changes may reverse themselves in response to recent reductions in harvest rates. Stray early-run coho from Eagle Creek Hatchery account for half or more of the fish surveyed in spawning areas within the portion of the subbasin below the sorting facility at Faraday (McElhany et al. 2007), although in Clear Creek, a major tributary that enters the Clackamas below the sorting facility, no hatchery-origin spawners have been found with natural-origin fish (Suring et al. 2006).

4.8.2.4 LCR Chum Salmon

McElhany et al. (2007) noted that chum salmon are now rarely observed in any of the Oregon tributaries to the lower Columbia River but that it is likely some low level of spawning has gone undetected in some areas. Recent genetic analysis of Washington chum suggests that very small remnant populations may have persisted even when there have been no consistent observations of fish (Small et al. 2006). Regardless, a lack of recent sightings of chum in the Clackamas subbasin suggests that the species is either absent or very nearly so. USFWS (2007) indicates that the species is “functionally extinct” in the subbasin.

4.8.2.5 LCR Steelhead

Population Viability

The population of LCR steelhead native to the Clackamas subbasin is in better condition than other Oregon populations within this evolutionary group. An assessment of the Clackamas population’s abundance, productivity, spatial structure, and diversity suggests a low to moderate risk of extinction (McElhany et al. 2007). Contributors to risks the population faces include:

- habitat degradation in the lower Clackamas subbasin and passage conditions [which are being improved] at PGE’s hydroelectric dams on the mainstem Clackamas (WRI 2004)
- potential genetic introgression from a non-local hatchery stock of winter steelhead that is now excluded from the upper subbasin but may still stray into natural spawning areas in the lower subbasin (McElhany et al. 2007);
- competitive displacement of native winter steelhead by introduced hatchery-origin summer steelhead that are now excluded from the upper subbasin but still present in the lower subbasin (Kostow et al. 2003)
- potential legacy effects on population productivity and diversity of a 22+ year period when the native run was excluded from habitats in the upper Clackamas subbasin (SPC&A 2001); and
- potentially catastrophic events with a moderate probability of occurrence, such as landslides, disease outbreaks from hatchery operations, and pollutant spills (WLCTRT 2003).

Abundance & Productivity

The Clackamas’ native winter steelhead population has a long-term geometric mean abundance of about 1,800 natural origin spawners (McElhany et al. 2007), and has recently rebounded from low abundances recorded during the 1990s (Chilcote 2007; Figure 4.8-5). The population’s abundance is high enough to suggest a low extinction risk, but there is moderate uncertainty in this assessment because of difficulties in evaluating the effects of stray hatchery fish and other factors on population productivity (McElhany et al. 2007).

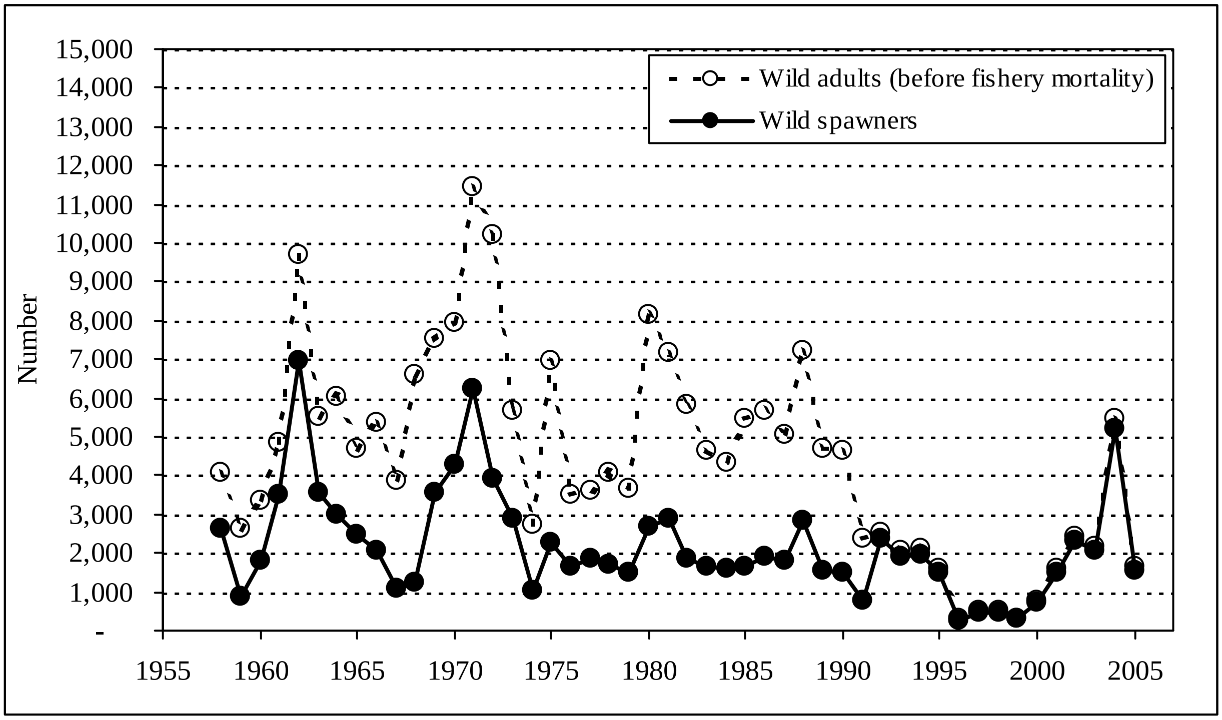


Figure 4.8-5 Estimated abundance of natural-origin ("wild") Clackamas late-run winter steelhead, 1958-2005 (data source: Chilcote 2007).

Spatial Structure

The spatial structure of Clackamas winter steelhead suggests a low risk of extinction, with moderate uncertainty (McElhany et al. 2007). Virtually all of the habitat historically accessible to winter steelhead in the Clackamas subbasin remains accessible to them (ODFW 2005b), but the population's spatial structure has been affected by substantial habitat degradation in lower portions of the subbasin.

Diversity

McElhany et al. (2007) rated the diversity of the Clackamas' native population of winter steelhead as reflecting a low to moderate risk of extinction, based on an examination of life history traits, effective population size, hatchery impacts, anthropogenic mortality, and habitat diversity. Their key concerns included the presence of non-native hatchery stocks of winter and summer-run steelhead in the lower subbasin, potential lingering effects of the 20+ year period of exclusion from the upper subbasin during the early 1900s, and diminished habitat quality in the lower subbasin.

4.8.2.6 Limiting Factors and Threats to Recovery

Factors unfavorably affecting the status of the Clackamas population of UWR Chinook and the Clackamas subbasin's other ESA-listed populations of anadromous salmonids include a variety of within-basin dam effects, including imperfect fish passage, large hatchery programs, and the cumulative effects of multiple land and water use practices on aquatic habitat. Habitat degradation is a particular concern in the lower Clackamas subbasin, below the dams, where the historic capacity to produce anadromous salmonids has been substantially diminished (WRI 2004). Conditions affecting fish from these populations when in the lower mainstem Willamette and Columbia Rivers, some of them related to USACE Project dams and operations, are discussed in sections 4.10 and 4.11.

4.8.3 Environmental Conditions

4.8.3.1 Habitat Access

Anadromous salmonid passage to and from their habitats within the Clackamas subbasin is affected by PGE's Clackamas River Hydroelectric Project and by migration impediments at road crossings of small streams (WRI 2004). Fish passage conditions at the hydroelectric project have been an important factor limiting anadromous fish production in the upper portion of the Clackamas subbasin (WRI 2004). Deficient conditions at road crossings are remedied as opportunities are identified.

Upstream Passage of Anadromous Fish at the Clackamas River Hydroelectric Project
Facilities for the passage of upstream migrating salmonids are currently provided at all three of PGE's hydroelectric dams on the mainstem Clackamas River (Figure 4.8-6). Upstream passage is provided by two fish ladders: (1) the River Mill fish ladder, which provides passage over River Mill Dam into Estacada Lake; and (2) the Faraday-North Fork fish ladder, which spans 1.7 mi (2.7 km), allows sorting of fish at a trap near its entrance, and provides passage over both Faraday Diversion Dam and North Fork Dam. At the sorting trap, natural origin fish are returned to the ladder to resume their upstream migration, and hatchery fish are removed so they do not continue up the ladder. As part of the Biological Opinion on the Interim Operation of PGE Projects (NMFS 2003c) associated with relicensing the hydroelectric project, the River Mill ladder has just been rebuilt by PGE to bring its design and performance up to modern standards. Operational measures, such as a pulsed-flow regime down the Faraday Bypass reach, are being evaluated for their effectiveness at encouraging adult spring Chinook salmon to avoid potential migration delays at the Faraday Powerhouse and below the entrance to the Faraday-North Fork fish ladder.

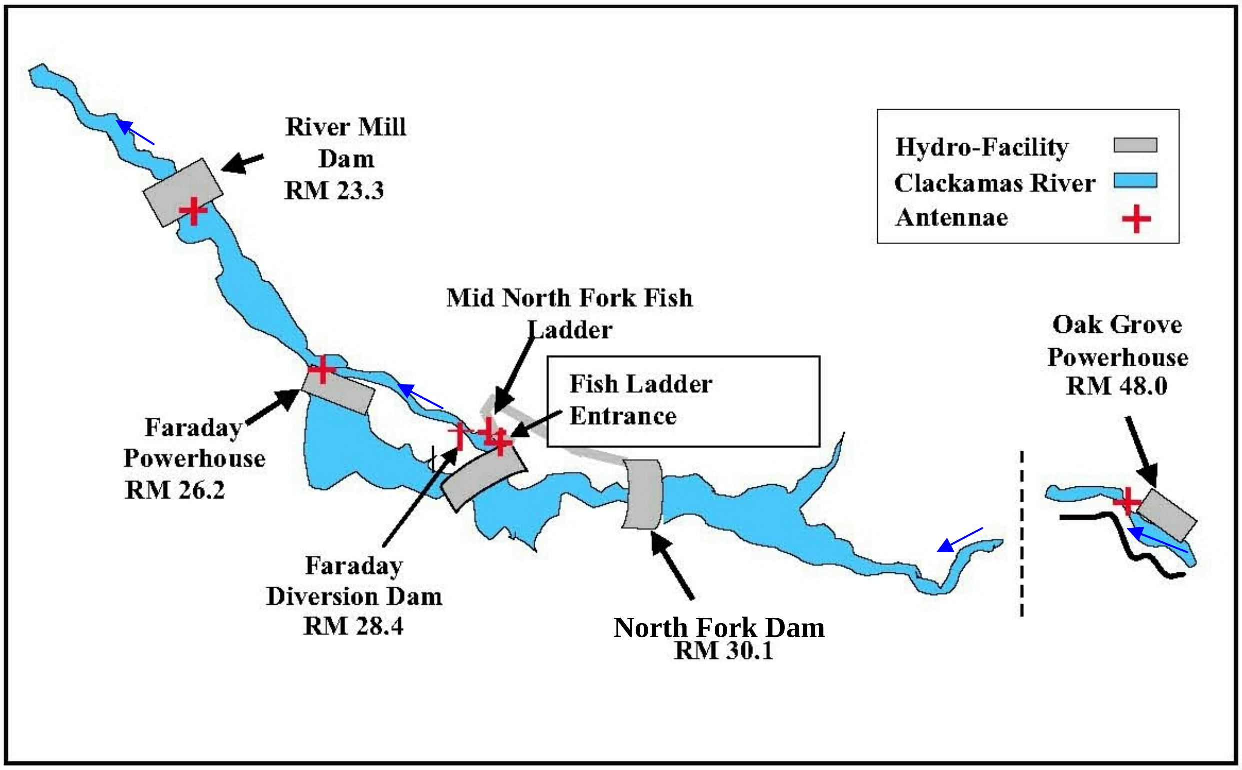


Figure 4.8-6 PGE hydroelectric dams on the mainstem Clackamas River (source: Shibahara et al. 2001).

Downstream Passage of Anadromous Fish at the Hydroelectric Project

PGE operates downstream fish passage facilities at the North Fork and River Mill dams, but not at Faraday Dam or the Faraday Powerhouse. The juvenile bypass facility at North Fork Dam, considered only partly effective (FERC 2006), consists of a surface collection system, the Faraday-North Fork fish ladder, a separator, an evaluation station, and a bypass pipeline. A portion of the juvenile salmonids migrating downstream from the upper Clackamas subbasin are attracted to a surface collection facility in North Fork Reservoir and are passed into the Faraday-North Fork fish ladder. Near the lower end of the 1.7-mi (2.7 km) long fish ladder, the downstream migrants pass through a "separator," where they are screened out, passed through a passive integrated transponder (PIT)-tag detector, and then diverted into a pipeline that conveys them 5 mi (8 km) to the tailrace of River Mill Dam. The separator also collects a sample of fish into a holding box where they are counted, passed through a PIT-tag detector, and measured before being released into the downstream migrant pipeline. The outlet of the pipeline was just renovated to provide added protection of juvenile downstream migrants. Spilled flows up to 500 cfs pass through a screen that diverts juveniles to the juvenile bypass facility. Spilled flows exceeding 500 cfs are not screened and attract fish to a spillway shown to cause high levels of injury and mortality.

PGE follows spill management protocols at Faraday Dam that encourage fish to pass into the Faraday Bypass reach, rather than toward the Faraday Powerhouse via its diversion canal, whenever spills over North Fork Dam pass juveniles downriver. These protocols compensate for the lack of fish passage structures at Faraday and will remain in effect until the partial forebay net to be constructed at North Fork is proven effective.

River Mill Dam, originally constructed in 1910–1911, is an 85 ft high spillway dam and power-house between rock abutments. Since its initial construction there have been multiple modifications to address safety concerns and to improve fish passage, but recent evaluations identified additional passage improvements that would be helpful. As part of the Biological Opinion on the Interim Operation of PGE Projects (NMFS 2003c) associated with relicensing the hydroelectric project, PGE has modified the dam's spillway to limit injury and mortality of juvenile salmonids passing downstream via that route,

Other Passage Impediments

Fish passage is impeded or blocked at multiple road crossings of small tributary streams in both the upper and lower portions of the Clackamas subbasin, and affects fish access to historical coho and steelhead habitat within both areas (WRI 2004). Such barriers are likely more frequent along tributary streams in the lower subbasin due to higher road density than in the upper subbasin. Within the Deep and Goose Creek watersheds, for example, WPN (2005) identified 39 partial or total migration barriers on fish-bearing streams. Artificial structures such as the dams that create farm ponds, common in the lower subbasin (WPN 2002, 2005), may also affect fish access to some areas.

4.8.3.2 Water Quantity/Hydrograph

Natural streamflows in the Clackamas subbasin, those to which the native salmonids are adapted, are similar to those described for other eastside tributaries to the Willamette River elsewhere in this document. Flows from the upper subbasin are greatest during major winter storms, remain relatively high during spring snowmelt, and decline during the summer dry season. Streams lower in the subbasin drain watersheds that receive little snowfall, are dominated by rainfall runoff, and experience earlier declines in flow than are seen at higher elevations in the upper subbasin. Natural streamflows in tributaries to the lower Clackamas tend to be very low during summer and early fall.

Flows within many of the subbasin's streams have been influenced by landuse, but such changes are generally subtle in comparison to the effects of direct diversions of water for hydroelectric power generation, irrigation, residential use, or municipal and industrial use. PGE's hydroelectric project has substantial local effects on flows in sections of the lower Oak Grove Fork and the mainstem Clackamas River that are important to anadromous salmonids. Other consumptive uses of water have altered seasonal flow patterns within lower portions of the subbasin, exacerbating low flow conditions and contributing to elevated water temperatures in many stream channels used by these fish.

4.8.3.2.1 Flow Reductions

Reductions for Hydropower Production

Flow patterns in the 4.4 mile section of the Oak Grove Fork naturally accessible to anadromous fish, and in the 4.9 miles of the Clackamas River from the mouth of this tributary to PGE's Oak Grove Powerhouse, are affected by large diversions of water (up to 585 cfs) from the tributary and to the powerhouse at RM 48 on the mainstem Clackamas. Flows in the Oak Grove Fork below the diversion point were historically quite stable due to strong groundwater influences within its watershed, but have for decades been severely diminished by hydropower operations that greatly reduce flows year-round and cut summer-fall minimums within the reach from perhaps 250-300 cfs to 0-10 cfs (McBain and Trush 2004).

Flows in the mainstem Clackamas between the Oak Grove Fork and Oak Grove Powerhouse are most altered by hydropower operations during periods of low flow, when the tributary would naturally contribute about 40-50% of the flow found below its mouth (McBain and Trush 2004).

Between the Oak Grove Powerhouse and North Fork Reservoir, daily average flows in the Clackamas River are relatively unaffected by PGE's hydroelectric operations, but daily and weekly fluctuations downstream of the powerhouse are modified by power peaking (Gomez and Sullivan 2001). The peaking generally occurs on weekdays, in the morning and evening, and is discussed in section 4.8.3.2.2.

PGE also reduces flow substantially in the mainstem Clackamas River below Faraday Dam. Unless river flows exceed a diversion capacity of more than 5,000 cfs, a minimum flow of approximately 120 cfs has been maintained in the Faraday Bypass reach to provide upstream passage and rearing habitat for anadromous salmonids. This minimum constituted less than a quarter of the lowest flows reaching the dam each year. The sufficiency of the 120 cfs minimum flow, particularly for effective fish passage, has long been debated.

Below River Mill Dam, flows in the Clackamas River follow a natural seasonal pattern and cause localized flooding during many winters.

Consumptive Uses of Water

Valid rights for consumptive diversions of water from streams in the lower elevation watersheds tributary to Clackamas River below River Mill can approach or exceed natural summer low flows in some of these streams. Such situations have been documented in assessments of the Clear, Foster, Deep, and Goose Creek watersheds (WPN 2002, 2005). Although not all water rights are exercised concurrently when flows are at their lowest, water diversions within the lower subbasin do tend to reduce streamflows, diminish rearing space, and increase water temperatures in many of the smaller streams used by ESA-listed anadromous salmonid. For example, low summer flow conditions that appear barely adequate to unsuitable for salmonids have been reported in both the Rock and Richardson Creek watersheds (Ecotrust 2000).

Streamflow conditions within the lower Clackamas River's tributary watersheds differ from those in the mainstem, because flows in the lower mainstem benefit from sustained late-season water yields from the upper subbasin. However, what appears to be relatively abundant high-quality water has made the lower Clackamas a key source area for long-range plans to continue expanding the region's municipal/industrial water supply. The river now provides municipal water to over 200,000 residents in the Portland metropolitan region, and an increased demand for water is anticipated (EES 2004). At present, water providers, including the City of Lake Oswego, Clackamas River Water, the South Fork Water Board, and the North Clackamas County Commission, have Clackamas River water rights totaling nearly 300 cfs, about half of which are being exercised using existing diversion facilities. Expansions of diversion and treatment facilities by the water providers are anticipated (EES 2004), and may at some point conflict with salmon conservation objectives. Consultants to the providers (Annear and Wells 2006) have developed a model to address mainstem water availability questions and examined the potential for supplementing lower Clackamas River flows with water stored in the upper subbasin.

4.8.3.2.2 Flow Fluctuations, Entrapment & Stranding

Unnaturally rapid declines in flow can causes losses of small juvenile salmonids, as noted on multiple occasions earlier in this document. Such changes in flow and river stage have occurred in the past along the mainstem Clackamas as a result of PGE's operation of the Clackamas River Hydroelectric Project.

Potential losses of juvenile salmonids caused by rapid water-level fluctuations in the mainstem Clackamas downstream from power peaking operations at Oak Grove Powerhouse (RM 48) have been considered during field reconnaissance and hydraulic simulations of channel cross-sections measured at sensitive locations. Daily maximum down-ramp rates during summer and early fall (a period when salmonid fry are present and ramp rates are relatively high) were estimated to have averaged 0.17 ft/hr at the sensitive locations in 1998 and 0.16 ft/hr in 1999, and exhibited absolute peaks at 0.66 ft/hr each year (Doughty 2004). Studies summarized by Hunter (1992) suggest that the average rates estimated by Doughty should have been reasonably safe for small salmonids but not the annual peak rates.

Peaking operations at the Faraday Powerhouse are anticipated to pose lesser risks, because the powerhouse discharges almost directly into the upper end of the reservoir created by River Mill Dam (Estacada Lake).

4.8.3.3 Water Quality

4.8.3.3.1 Water Temperature

Salmonids are sensitive to changes in water temperature and can be unfavorably affected by shifts in thermal regimes during the summer rearing or spawning/incubation period. Unfavorable shifts in temperature have occurred in some streams used by anadromous salmonids in the upper Clackamas subbasin and a greater number of streams in the lower subbasin. For example, the ODEQ 2004/2006 Integrated Report database identifies 68.7 stream miles as exceeding temperature criteria for core salmonid rearing habitat ($16^{o}C$), including segments of Collawash R. and Fish Cr. in the upper subbasin, plus Eagle Cr., N. Fk. Eagle Cr., and Bear Cr. in the lower subbasin. A combined 25.5 miles of the lower Clackamas R. and Cow Cr. have been identified as exceeding temperature criteria for general salmonid rearing ($18^{o}C$), and an additional 25.1 miles of Eagle Cr., Nohorn Cr., and Collawash R. exceed temperature criteria for salmon and steelhead spawning habitat ($13^{o}C$).

Elevated temperatures in Clackamas River tributaries are attributable to altered riparian vegetation and, in the lower subbasin, diminished streamflows. However, water quality modeling identifies PGE's mainstem reservoirs as a significant source of heating and thermal alteration of the lower mainstem Clackamas (ODEQ 2006a, Figure 4.8-7). Heating that occurs in the reservoirs warms stored water and has caused a shift in temperature patterns downstream of River Mill Dam.

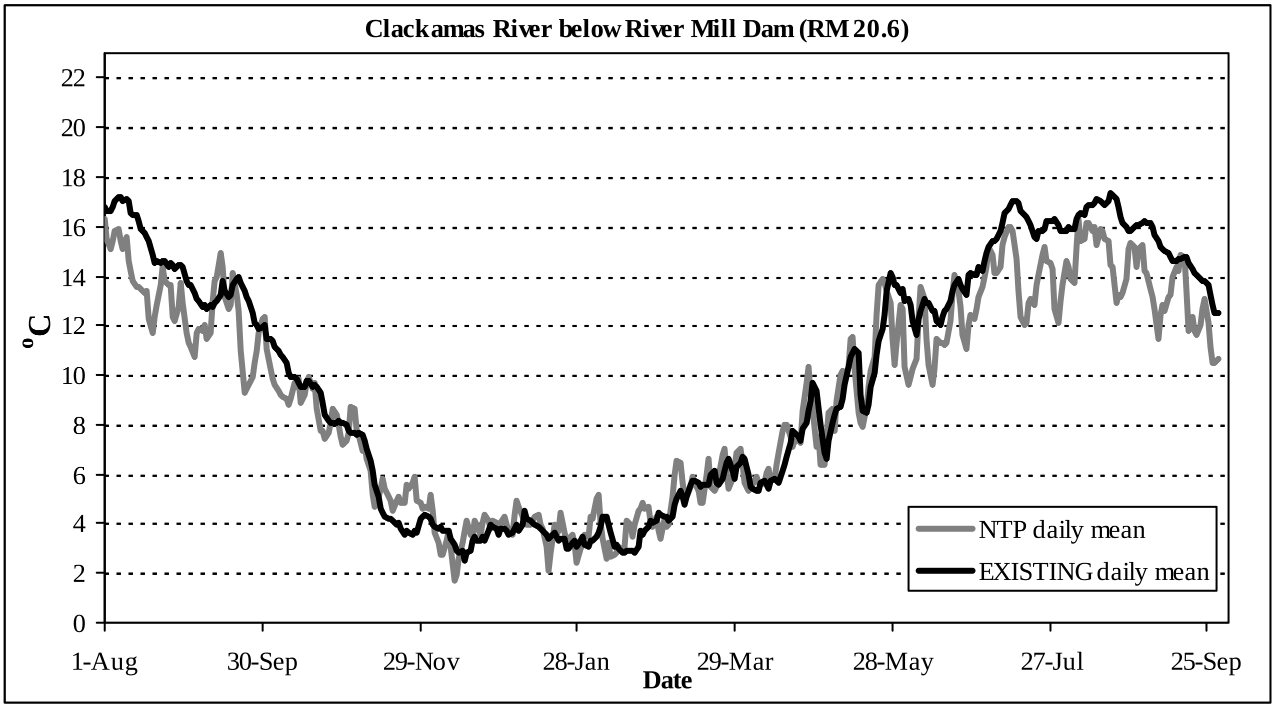


Figure 4.8-7 Simulated daily mean water temperatures in the Clackamas River below River Mill Dam for existing ("EXISTING") and no-dam (NTP) scenarios, August 2000 – September 2001 (data source: Arendt et al. 2008).

4.8.3.3.2 Other Water Quality Constituents

Dissolved Oxygen

Although Ecotrust (2000) suggests that low concentrations of dissolved oxygen occur in some small streams within the lower Clackamas subbasin, there is little data because monitoring of this water quality constituent in most of these streams has generally been limited. However, the ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as being water quality impaired due to low concentrations of dissolved oxygen.

Total Dissolved Gas

The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to excessive TDG levels.

Turbidity

Suspended sediment and turbidity levels have been elevated in some streams within the lower Clackamas subbasin (WPN 2002). However, the ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as being water quality impaired due to turbidity.

Nutrients/Contaminants
Nutrient levels are elevated in some streams within the lower subbasin but none of these streams are identified by the ODEQ 2004/2006 Integrated Report database as being water quality impaired for this reason. The database does, however, identify a combined 52.0 miles of 8 streams in the lower subbasin as water quality impaired by intermittently high concentrations of *E. coli* bacteria. These include the lower 15 miles of the mainstem Clackamas, as well as Deep Cr., N. Fk. Deep Cr., Tickle Cr., Cow Cr., Barfield Cr., Rock Cr., and Sieben Cr. There are a number of potential sources of the bacterial contamination, including livestock and poorly functioning septic systems in rural-residential areas. The Clackamas River itself receives effluent from Estacada and Clackamas waste treatment plants, and probably picks up contaminants from tributaries and non-point sources along its route.

Toxics
ODEQ has identified a risk of bio-accumulation of mercury in North Fork Reservoir.

4.8.3.4 Physical Habitat Characteristics

Unfavorable human influences on the physical characteristics of habitat for ESA-listed anadromous salmonids are greater in lower portions of the Clackamas subbasin, below River Mill, than they are above that dam. A key reason for this is the pattern of land ownership with most of the lower subbasin in private ownership and the upper subbasin publicly owned. Most of the upper subbasin is managed by the Mt. Hood National Forest which emphasizes aquatic conservation in its habitat management policies (USDA&USDI 1994).

Physical habitat quality is generally poorer in the lower subbasin due to reduced habitat diversity and increased levels of fine sediment (WRI 2004). The reductions in habitat diversity in the lower subbasin have been a function of a decline in large woody debris (LWD) and channel simplifications that have resulted from active manipulation and changes in riparian conditions. In many cases changes in stream conditions within the lower subbasin have been dramatic (SPC&A 2001). Habitat in the upper basin is in considerably better shape than that in the lower subbasin, but has also lost diversity in many areas due to reductions in LWD. These reductions have been due to changes in riparian forests and stream-cleaning efforts that occurred before the importance of wood in the creation and maintenance of high-quality salmonid habitats was fully understood.

Substrate
Substrate conditions within streams used by the Clackamas subbasin's ESA-listed salmonid populations have been influenced by the effects of varied land-use activities. These effects tend to be more pronounced in the lower subbasin, where WRI (2004) has identified elevated levels of fine sediments as a frequent limiting factor. Along the mainstem Clackamas, trapping of coarse sediments in PGE reservoirs prevents delivery of an average of more than 66,000 yd^3/yr of this material to the river channel below River Mill Dam (Wampler and Grant 2003). Over time this has caused dramatic riverbed coarsening, down-cutting, and channel simplification for 2 miles below the dam and contributed to changes in channel processes and features for as much as 9 miles below the dam (Wampler and Grant 2003). In combination with aggregate mining and isolation of the floodplain by bank protection structures, elimination of sediment delivery from

the upper subbasin has helped create a less dynamic lower river with fewer active sidechannels and less salmon spawning habitat.

Large Woody Debris

Streams within portions of the upper Clackamas subbasin retain substantial quantities of in-channel wood, but a combination of natural disturbances, timber harvest, road construction, and stream-cleaning have diminished the abundance of LWD and the condition of fish habitat in other parts of the drainage network above River Mill Dam (Everest et al. 1987; USFS 1988, 1995; Cramer et al. 1997). Past losses of LWD have been offset in some streams on the Mt. Hood National Forest by direct placements into channels where its abundance was low.

All LWD transported from watersheds above River Mill Dam is trapped within PGE reservoirs and cannot influence channel processes and habitat quality in the lower Clackamas River without active intervention. This lost LWD delivery has likely contributed to reductions in the complexity and quality of anadromous salmonid habitat in the river.

Similar losses of habitat function and quality due to reduced quantities of LWD have been common elsewhere in the lower subbasin. Past uses of channels and riparian vegetation have left instream abundances of LWD as well as wood recruitment potential low across much of the drainage network (SPC&A 2001; WPN 2002, 2005).

Channel complexity, Off-channel Habitat & Floodplain Connectivity

Stream channel complexity, off-channel habitats, and floodplain connectivity are important elements of high-quality salmonid habitat that have been reduced in the Clackamas subbasin, frequently as a result of low LWD abundance or direct channel manipulations. The reductions appear to have been acute in areas of relatively gentle topography within watersheds below River Mill, where agricultural development and urbanization often influence stream conditions. For example, WPN (2005) identified 21.5 miles of ditched channels in these types of areas within the Deep and Goose Creek watersheds. Off-channel habitat and floodplain connectivity along the lower Clackamas River have been affected by bank stabilization and diking (WRI 2004). The USACE maintains 1.6 miles of revetments it has constructed along the lower river between RM 1.5 and RM 20.1.

Riparian Reserves & Disturbance History

Riparian vegetation along streams within lower portions of the Clackamas subbasin is often recently disturbed or in early- to mid-successional stages as a consequence of man-caused disturbances, while that along streams within the upper subbasin more frequently includes older aged conifers (ODEQ 2006a). Conditions in the upper subbasin are improving, due to an increased focus on aquatic conservation by the U.S. Forest Service. However, the lower subbasin has predominantly private forestlands managed with less emphasis on aquatic conservation and is dominated by more intrusive agricultural, rural-residential, municipal, or industrial landuses in lowland areas or where the topography is gentle. Riparian vegetation provides variable but frequently good shading along streams in the lower subbasin, though along these streams it often consists of narrow bands of trees or shrubs and includes invasive species when bordered by non-forest landuses (Ecotrust 2000; WPN 2002, 2005). Along the lower Clackamas, bank protection structures such as the USACE revetments described in the last paragraph have removed riparian vegetation and contribute to deficiencies in LWD recruitment potential and shade. As indicated earlier, the near-term potential for riparian recruitment of LWD to streams is low across most of the lower subbasin.

4.8.4 Hatchery Programs

Hatchery programs for anadromous salmonids began operating in the Clackamas subbasin more than 100 years ago and have had a substantial influence on the subbasin's wild runs of fish. Descriptions of the earliest programs, which focused on spring and then fall Chinook salmon (SPC&A 2001), raise substantial questions about the harm done to these runs. More recent programs within the subbasin are believed to be far more effective at returning adult fish, because of improvements in hatchery practices that began in the 1950s and 1960s. Hatchery programs within the subbasin have expanded to propagate Chinook salmon, coho salmon, and steelhead.

Hatchery produced spring Chinook and early-run coho smolts are released into the lower Clackamas subbasin each year. These programs have in the past focused almost exclusively on fishery augmentation, but are being modified so as to improve their consistency with ESA mandates for the conservation of natural-origin fish runs. All hatchery-origin salmon released into the subbasin are fin-clipped, allowing managers to screen any strays, other than a fraction with imperfect or regenerated fin clips, out of the upper basin run at Faraday. This fraction has been as high as 26% at times as described above in 4.8.2.1.

There are also three hatchery stocks of steelhead that are currently released into the Clackamas River, early-winter (introduced), late-winter (native), and summer run (introduced). Since 1999, only unmarked steelhead (those presumed to be natural-origin) have been allowed to pass above North Fork Dam. The ODFW Clackamas Hatchery currently rears a winter run broodstock (122W) developed from unmarked fish at North Fork Dam. The Big Creek Hatchery stock of winter steelhead returns to the Clackamas River from October to early March, earlier than the February to June run timing of the native winter steelhead (Murtagh et al. 1992). Furthermore, the peak spawning period for Big Creek derived fish is January to early March compared with May and June for native Clackamas River winter steelhead

Hatchery summer steelhead that are released into the Clackamas River basin are fin-clipped and have been excluded from passage at North Fork since 1999. Prior to that time, these fish strayed to and spawned in streams within the upper subbasin that were used by wild winter steelhead (McElhany et al. 2007). The consequence for the wild late-winter fish was a reduction in productivity attributed to competition with the juvenile offspring of the summer steelhead (Kostow et al. 2003). The potential for stray hatchery summer steelhead to spawn and compete in streams with wild late-winter steelhead still present in the lower subbasin has not been studied.

4.8.5 Harvest

Recent harvest rates on the wild runs of ESA-listed anadromous salmonids in the Clackamas subbasin vary by species. Recently instituted marks-only regulations for the sport fishery and precautionary management of Columbia River commercial fisheries have lowered harvest mortality rates on the Clackamas subbasin's wild population of UWR (spring) Chinook from an average of about 55% prior to its listing under the ESA to approximately 20% today (Chilcote 2007). The freshwater sport and commercial fisheries are causing about half of this mortality, with the remainder reflecting an assumption of loss rates in ocean fisheries. Harvest rates on wild fall-run LCR Chinook such as are found at very low abundance in the lower Clackamas at present are managed to stay below a maximum combined Rebuilding Exploitation Rate (RER) of 49% in all ocean and freshwater fisheries. Freshwater harvest of wild LCR chum salmon is not allowed in Oregon and incidental handling in fisheries for other species is managed to keep maximum take below 2%. Harvest-related mortality rates for the Clackamas' wild, late-run populations of coho salmon and winter steelhead are now about 30% and 5%, respectively (Chilcote 2007).

There is a very popular steelhead sport fishery on the Clackamas River. However, all hatchery steelhead are now fin-clipped and it is illegal to retain wild steelhead. Other than hooking mortality during catch-and-release, there appears to be little negative effect from harvest on wild LCR steelhead populations in the Clackamas.

4.8.6 Status of PCEs of Designated Critical Habitat in the Clackamas Subbasin

NMFS has determined that the following occupied areas of the Clackamas subbasin contain Critical Habitat for UWR Chinook, LCR Chinook, LCR Coho, LCR Chum, and LCR Steelhead (NMFS 2005g; NMFS 2005d – Maps are included in Section 3.3 of this Opinion):

UWR Chinook (spring-run)

- Habitat of high conservation value for these fish, and thus important to their recovery, is present within five of the six watersheds within the Clackamas subbasin. This habitat includes 110.4 miles of PCEs for spawning/rearing, 18.7 miles of PCEs for rearing/migration, and 0.0 miles for migration/presence (NMFS 2005g). All five of the watersheds containing habitat of high conservation value were designated as Critical Habitat (NMFS 2005d), as listed below:
  - The Collawash River watershed contains 16.9 miles of spawning/rearing habitat and 0.2 miles of rearing/migration habitat (NMFS 2005g).
  - The Upper Clackamas watershed contains 23.7 miles of spawning/rearing habitat and 1.8 miles of rearing/migration habitat (NMFS 2005g).
  - The Oak Grove Fork watershed contains 4.0 miles of spawning/rearing habitat (NMFS 2005g).
  - The Middle Clackamas watershed contains 33.9 miles of spawning/rearing habitat and 3.3 miles of rearing/migration habitat (NMFS 2005g).
  - The Lower Clackamas watershed contains 22.9 miles of spawning/rearing habitat and 13.4 miles of rearing/migration habitat (NMFS 2005g).
- Habitat of low conservation value to UWR Chinook was not designated as Critical Habitat (NMFS 2005d). The Eagle Creek watershed was given a low conservation value to UWR Chinook and contains 13.8 miles of spawning/rearing habitat and 3.2 miles of rearing/migration habitat (NMFS 2005g).

LCR Chinook (fall-run)

- These fish are found in two watersheds within the Clackamas subbasin, Lower Clackamas River and Eagle Creek (NMFS 2005g).
- The Lower Clackamas River watershed contains habitat of high conservation value for LCR Chinook that was designated as Critical Habitat (NMFS 2005d). This watershed segment contains 34.8 miles of spawning/rearing habitat and 2.7 miles of rearing/migration habitat (NMFS 2005g).
- Habitat of low conservation value to LCR Chinook was not designated as Critical Habitat (NMFS 2005d). The Eagle Creek watershed was given a low conservation value to LCR Chinook and contains 13.8 miles of spawning/rearing and 3.2 miles of rearing/migration habitat (NMFS 2005g)

LCR Coho Salmon

- NMFS has not yet designated Critical Habitat for this evolutionary group of anadromous salmonids, although these fish are found throughout much of the lower Clackamas subbasin and in portions of the upper subbasin.

LCR Chum Salmon

- NMFS did not designate Critical Habitat for LCR Chum Salmon within the Clackamas Subbasin (NMFS 2005d).

LCR Steelhead

- Habitat of high conservation value for these fish, and thus important to their recovery, is present within all six watersheds within the Clackamas subbasin. This habitat includes 263.3 miles of PCEs for spawning/rearing, 12.4 miles of PCEs for rearing/migration, and 2.8 miles for migration/presence (NMFS 2005g). The habitat in all of these watersheds, listed below, was designated as Critical Habitat for LCR Steelhead (NMFS 2005d).
  - The Collawash River watershed contains 34.0 miles of spawning/rearing habitat (NMFS 2005g).
  - The Upper Clackamas watershed contains 53.0 miles of spawning/rearing habitat (NMFS 2005g).
  - The Oak Grove Fork watershed contains 4.2 miles of spawning/rearing habitat (NMFS 2005g).
  - The Middle Clackamas watershed contains 45.6 miles of spawning/rearing habitat, 2.5 miles of rearing/migration habitat, and 0.4 miles of migration/presence habitat (NMFS 2005g).
  - The Lower Clackamas watershed contains 89.8 miles of spawning/rearing habitat and 9.9 miles of rearing/migration habitat, and 2.4 miles of migration/presence habitat (NMFS 2005g).
  - The Eagle Creek watershed contains 36.7 miles of spawning/rearing habitat (NMFS 2005g).

Table 4.8-1 summarizes the condition of PCEs within the Clackamas subbasin. All of the habitat indicators reflect sub-optimal conditions for salmon and steelhead.

Table 4.8-1 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the Clackamas subbasin under the environmental baseline.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater migration corridors	Habitat Access	Physical Barriers	Up- and downstream fish passage conditions at the Clackamas River Hydroelectric Project are a key limiting factor for upper basin fish runs.	Hydroelectric dams and reservoirs
Freshwater migration corridors	Habitat Access	Physical Barriers	Culverts beneath road crossings of streams impair anadromous fish access to some historical habitats within the upper subbasin. Culverts beneath road crossings and other physical structures on streams in the lower subbasin impede or block anadromous fish movements into some historical habitats within the lower subbasin.	Forest roads Roads or other structures associated with forestry, agriculture, rural-residential land use, and urbanization

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/Hydrology)	Change in Peak/Base Flow	Naturally low summer flows are exacerbated in the lower subbasin by water withdrawals	Agricultural, rural-residential, municipal, and industrial development.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	The ODEQ 2004/2006 Integrated Report database identifies 68.7 stream miles as exceeding temperature criteria for core salmonid rearing (16^{o}C), including segments of Bear Cr., Eagle Cr., and N.Fk. Eagle Cr. in the lower subbasin, and Collawash R. and Fish Cr. in the upper subbasin. The database also identifies a combined 25.5 miles of the lower Clackamas R. and Cow Cr. as exceeding criteria for general salmonids rearing (18^{o}C). The ODEQ 2004/2006 Integrated Report database identifies 25.1 miles of Eagle Cr., Nohorn Cr., and Collawash R. as exceeding criteria for salmon and steelhead spawning (13^{o}C)	Forest practices, agriculture, rural-residential development PGE hydroelectric reservoirs, land use practices Forestry and other landuse practices

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin as water quality impaired due to turbidity.	NA
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Contaminants/Nutrients	The ODEQ 2004/2006 Integrated Report database identifies a combined 52.0 miles of 8 streams in the lower subbasin as water quality impaired by high concentrations of E. coli bacteria. These include the lower mainstem Clackamas, Deep Cr., N. Fk. Deep Cr., Tickle Cr., Cow Cr., Barfield Cr., Rock Cr., and Sieben Cr. Nutrient levels are elevated in some streams within the lower subbasin but none are identified by the ODEQ database as being water quality impaired for this reason.	Livestock, rural-residential, and municipal development. Agricultural and rural-residential development

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to low dissolved oxygen.	NA
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	The ODEQ 2004/2006 Integrated Report database does not identify any streams within the Clackamas subbasin that are known to have water quality impairment due to excessive TDG levels.	NA

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites	Habitat Elements	Substrate	Channel substrate conditions within the Clackamas subbasin reflect the cumulative effects of past watershed development and current landuse. Elevated levels of fine sediments have the potential to limit salmonid production in the lower subbasin. Reservoirs above dams on the mainstem Clackamas River trap coarse sediment and block its delivery from the upper subbasin to the lower river. This has affected channel complexity and the availability of spawning gravels below River Mill Dam	Forest practices, road construction, and riparian alteration due to near-stream agricultural, rural-residential, and municipal development PGE hydroelectric dams and reservoirs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Large woody debris (LWD) abundance and recruitment potential have been reduced along many streams, particularly in the lower subbasin where private lands predominate. Reservoirs above dams on the mainstem Clackamas River trap LWD and block its delivery from the upper subbasin to lower river. This has affected the complexity and quality of salmonid habitat in the lower Clackamas.	Forest practices, riparian alteration due to near-stream development, active wood removal PGE hydroelectric dams and reservoirs

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Channel complexity, Off-channel Habitat, and Floodplain Connectivity.	Channel complexity and the availability of off-channel habitats important to juvenile salmonids has been reduced by reductions in LWD, direct channel alterations that have included USACE construction of revetments along the lower Clackamas River, reduced coarse sediment supply in the Clackamas River below River Mille Dam, and floodplain development.	Historic logging and use of streams for log transport Direct channel modifications Forestry, agriculture, rural-residential, and other development. USACE revetments PGE hydroelectric dams and reservoirs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Road density and location	Road densities are moderate to high across large portions of the Clackamas subbasin, and are generally highest in the lower subbasin.	Forestry, agriculture, rural-residential and other development.

PCE	Pathway	Indicator	Condition	Limiting Factor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves/Disturbance History	Forests in both the upper and lower portions of the subbasin have an abundance of early- to mid-successional stages, with many forestlands in the lower subbasin having been harvested at least two or three times. The lower subbasin is partially forested but is generally dominated by agricultural, rural-residential, municipal, or industrial landuses in lowland areas or where the topography is gentle.	Timber harvest Other land uses
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves /Disturbance	Riparian vegetation in both the upper and lower portions of the Clackamas subbasin is frequently in early- to mid-successional stages as a consequence of past human-caused disturbances. Conditions in the upper subbasin are improving, due to an increased focus on aquatic conservation by the U.S. Forest Service. Riparian conditions in the lower subbasin, particularly in areas of low topographic relief where agricultural, rural-residential, or municipal landuses predominate near streams are often poor. Opportunities for improvement may be limited in urbanizing areas.	Forest practices, agricultural practices, rural-residential development, and urbanization.

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Section 4.9
Coast Fork & Long Tom Baseline

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4.9 COAST FORK & LONG TOM SUBBASINS

Seven subbasins drain all but a very small fraction of the west side of the Willamette Basin, between the mainstem Willamette River and the Coast Range (Figure 4.9-1). These westside subbasins include the Coast Fork Willamette, Long Tom, Marys, Luckiamute, Rickreal, Yamhill, and Tualatin. The Coast Fork (draining 665 mi^2) and Long Tom (410 mi^2) are both currently occupied by UWR Chinook (rearing juveniles) and are affected by USACE flood control operations. In addition, the USACE is consulting on the maintenance of revetments in the Row River (Coast Fork subbasin). Therefore, the Coast Fork and Long Tom subbasins below the Corps dams are within the action area for this consultation. Westside subbasins differ in several respects from those found in the eastern portion of the basin and discussed earlier in this document. Westside subbasins tend to have gentler topography, lower elevation headwaters, no spring snowpack, and summer baseflows that are naturally quite low. The majority of forestland within each subbasin is privately owned, and about half or more of that in the Long Tom lies within lowland areas converted to agricultural, rural-residential, or other ecologically disruptive land uses. Efforts to restore anadromous salmonid habitat within these subbasins will generally depend more strongly upon changes in private land management than will be the case in most of the Willamette's eastside subbasins. Due to relatively limited historical use by anadromous salmonids and uncertainty that they ever supported persistent, self-sustaining runs of UWR Chinook or UWR steelhead (Meyers et al. 2003), the westside subbasins are not anticipated to be a major focus of efforts to recover these fish (e.g., see ODFW 2007b).

In the Coast Fork subbasin, Cottage Grove Dam on the Coast Fork Willamette River (RM 29) and Dorena Dam on the Row River (RM 7.5) lack passage facilities. Above these two dams, the Umpqua National Forest and the Bureau of Land Management's Eugene District manage federally-owned public lands for multiple uses, and privately-owned lands are generally used for timber production and some agriculture. Mercury mined or leached from rich deposits above both dams creates health risks in waterbodies downstream (ODEQ 2006a). In addition, sand and gravel are mined from the channels in the lower Coast Fork Willamette and Row rivers, and adjacent bottomlands have been developed for agriculture.

Fern Ridge Dam on the Long Tom (RM 15) has regulated flow since 1941. The lower reaches have been extensively modified (channels straightened and diked for flood control). The river was severely degraded prior to dam construction, and Parkhurst et al. (1950) stated that its value to anadromous salmonids was doubted in 1938. Lowland portions of the subbasin are dominated by agriculture but include the urban landscape found in and around the city of Eugene (Thieman 2000).

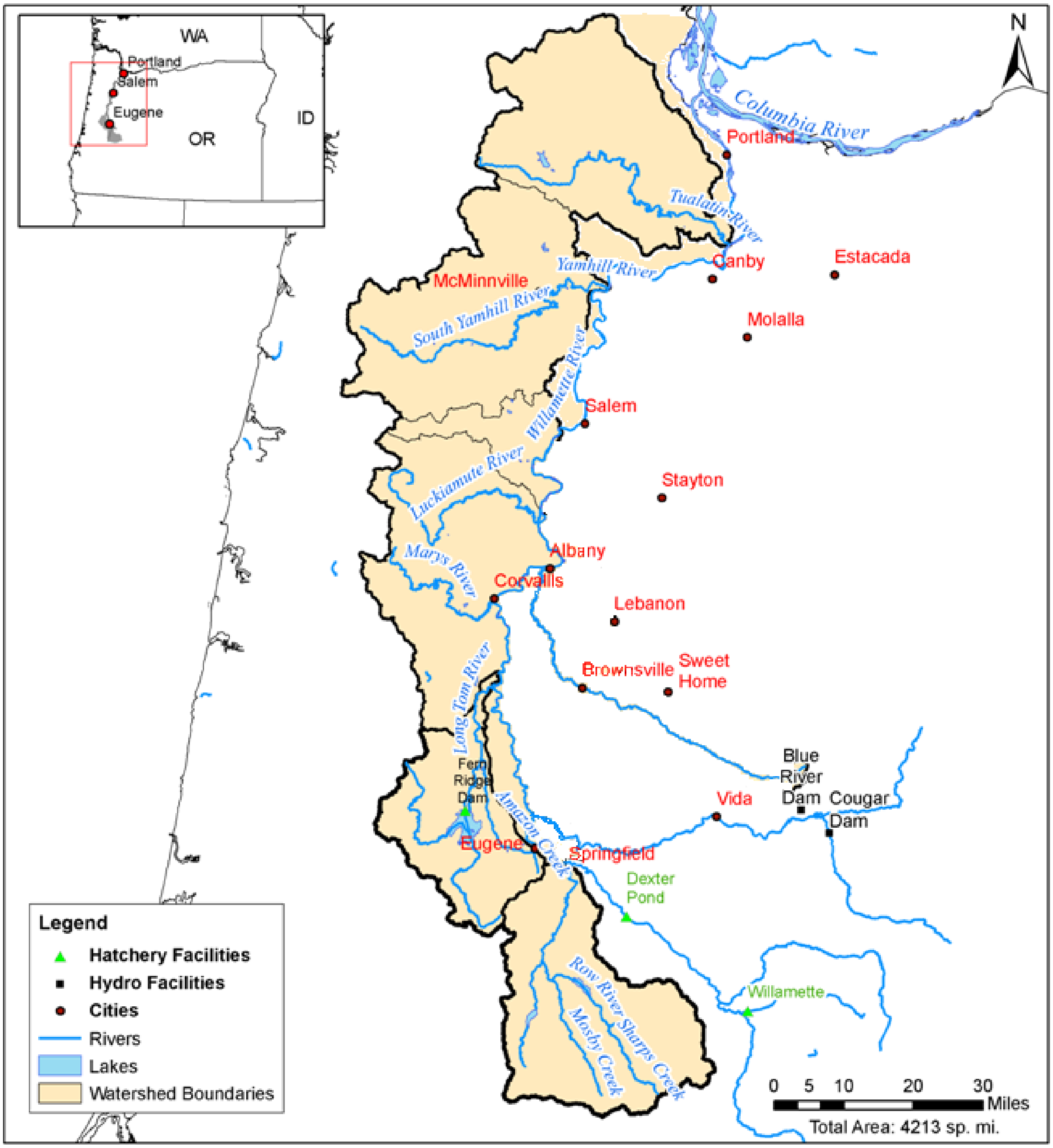


Figure 4.9-1 Map of the Willamette Basin with an emphasis on the Coast Fork Willamette and Long Tom

4.9.1 Historical Status of Anadromous Salmonids in the Coast Fork Willamette and Long Tom Subbasins

4.9.1.1 UWR Chinook Salmon

The Myers et al. (2002) did not identify either the Coast Fork or Long Tom subbasin as having supported a historical, demographically independent population of UWR Chinook salmon. However, the lower (valley floor) reaches of these streams were likely important as seasonal rearing areas for juvenile Chinook from populations that spawned in the Willamette's eastside tributaries. Historical accounts do indicate that small numbers of spawning UWR Chinook were once present in the Coast Fork (Dimick and Merryfield 1945), but these stocks had become depleted by the time their presence was documented by biologists.

The historical distribution and abundance of UWR Chinook within the Coast Fork subbasin are uncertain. Native spring-run Chinook were reported to have once spawned in the Row River drainage above the site of Dorena Dam (Dimick and Merryfield 1945), but any native run was probably extirpated by splash dams used in early logging operations (USFWS 1948). Even less is known about the historical use (or lack of use) of other parts of the subbasin. A 1938 survey by the Bureau of Commercial Fisheries attributed a lack of anadromous salmonids in the mainstem Coast Fork at that time to artificial passage obstructions and water pollution (McIntosh et al. 1995).

4.9.1.2 UWR Steelhead

Information on the historical distribution of UWR steelhead above Willamette Falls is incomplete, but it is generally thought that significant populations of these fish were restricted to the Willamette's largest eastside tributary systems from the Calapooia downriver to the Molalla. WLCTRT (2003) identified four historically independent populations above the Falls, each within a subbasin draining the Cascade Range, but none native to the Willamette's westside subbasins.

4.9.2 Current Status of Anadromous Salmonids in the Coast Fork Willamette and Long Tom Subbasins

4.9.2.1 UWR Chinook Salmon

Little information exists regarding the current abundance of naturally produced UWR Chinook salmon in the Coast Fork Willamette and Row rivers. Myers et al. (2003) did not consider UWR Chinook that spawn and rear in the Coast Fork subbasin likely to constitute an independent population. Symbiotics (2005) found no adult or juvenile Chinook salmon during surveys in the lower Row River below Dorena Dam in 2003 through 2005.

In multiple years since 1998, ODFW released adult hatchery-origin spring Chinook into Mosby Creek, the largest below-dam tributary to Row River, to see whether these fish would spawn successfully and produce viable offspring in that stream (Table 4.9-1). This effort became more formal in 2006, when ODFW began to record water quality in the area, survey spawning areas, estimate the habitat capacity of Mosby Creek, and trap juvenile Chinook produced by the outplanting effort (Moberly 2008). Results of this monitoring have shown that pre-spawn mortality is relatively high (59% of 73 carcasses recovered during 2006 and 2007 failed to spawn); however, some of the adult fish released into Mosby Creek are spawning successfully in the stream and some of its tributaries and are producing juvenile spring Chinook (Moberly 2008).

Table 4.9-1 Annual numbers of adult, hatchery-origin spring Chinook salmon released (outplanted) into Mosby Creek in the Coast Fork Subbasin, 1998-2007

Year	Number of adult spring Chinook released into Mosby Creek
1998	221
1999	0
2000	212
2001-05	0
2006	119
2007	43

The Long Tom subbasin is not thought to have supported a spawning population of anadromous salmonids. Recent sampling by ODFW indicates that yearling Chinook may over-winter in the lower Long Tom, when temperatures are within criteria for salmonid rearing (Kenaston 2003). Schroeder et al (2005) found juvenile Chinook during winter in non-natal tributaries to the Willamette as far as 23.3 miles from the mainstem; however he did not report finding them this high in the Long Tom River. Small dams in the river's lower 12 miles (as described in section 4.9.3.1) likely block juvenile and adult fish from accessing much of the Long Tom. Additionally, fish habitat from Fern Ridge Dam downstream to the mouth has been lost as a result of flow management from Fern Ridge Dam, land use changes, and bank protection projects. These past and ongoing actions have degraded riparian vegetation, floodplain function, large wood and sediment transport functions, and channel complexity.

4.9.2.2 UWR Steelhead

Modest numbers of naturally spawning steelhead are present now in some of the Willamette's westside tributaries, but there is considerable debate as to whether the existing fish are native or derived from introduced stocks (Myers et al. 2003). Hatchery summer steelhead have been observed spawning in the Coast Fork subbasin, but Parkhurst et al. (1950) did not report the presence of winter steelhead in westside streams.

4.9.2.3 Limiting Factors and Threats to Recovery

UWR Chinook and UWR steelhead, particularly those populations that are key to the long term viability of their respective species, make limited use of aquatic habitats in the westside subbasins. Habitats within these subbasins that are most frequently used by the eastside populations are seasonally suitable (i.e., fall-winter) lowland channels or associated backwater areas near the mainstem Willamette River. These habitats have been substantially degraded by direct alterations of stream channels and floodplains as well as by more than a century of cumulative watershed effects (USACE 2000, WRI 2004, and others). The degraded condition of these habitats likely has small, negative effects on the abundance and productivity of the ESA-listed populations that use them.

4.9.3 Environmental Conditions

Environmental conditions within the westside subbasins that affect UWR Chinook or UWR steelhead are described below. These habitat elements and their existing baseline condition are summarized in Table 4.9-3 at the end of this section.

4.9.3.1 Habitat Access

A number of migratory obstacles and barriers affect the ability of salmonids to migrate freely within the westside subbasins (WRI 2004). These include a variety of low and high dams plus large numbers of road culverts that are partial or complete fish barriers. The general relationship between such migratory impediments and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E.

Six dams constructed by the USACE have the potential to impede anadromous salmonid access to habitats in the Coast Fork and Long Tom subbasins: Dorena and Cottage Grove in the Coast Fork subbasin, and Fern Ridge plus three smaller dams (Monroe, Stroda, and Ferguson) on the mainstem Long Tom River.

Dorena & Cottage Grove Dams in the Coast Fork Subbasin

There are no up- or down-stream passage facilities at either of these dams. However, as described in section 4.9.1.1, UWR Chinook may once have used areas above these dams for spawning and rearing, but few native anadromous salmonids now stray into the Coast Fork or Row River.

Barriers below Fern Ridge Dam on the Long Tom River

A 10-foot high concrete grade-control dam spans the Long Tom River at the town of Monroe (RM 6.7) and two more grade-control dams (Stroda at RM 10.2 and Ferguson at RM 12.7). These small dams were constructed by the USACE to address channel erosion associated with the Project and only one (Monroe) has a fish ladder. Schroeder and Kenaston (2004) noted that juvenile Chinook were captured near the lower dam at Monroe. The ladder at the Monroe Dam is in disrepair and probably does not effectively pass juvenile fish into upstream rearing habitat in the Long Tom River. Neither of the other two grade-control dams is equipped with passage structures.

Fern Ridge Dam on the Long Tom River

The USACE owns and operates Fern Ridge Dam on the Long Tom River (RM 25.7). The dam lacks fish passage facilities. However, there is no evidence that juvenile Chinook or steelhead use habitat that far upstream, and the lack of passage facilities at two of the grade-control dams downstream likely precludes them from reaching Fern Ridge Dam.

4.9.3.2 Water Quantity/Hydrograph

Westside subbasins experience high streamflows during late fall through winter followed by declining or low flows until fall. Natural low summer and early fall flows in these subbasins limit habitat availability for salmonids and the situation is exacerbated by diversions from streams for agricultural, domestic, and industrial uses. Permits that have been issued for such diversions often have aggregate flow volumes that exceed the amount of water naturally available during low flow periods. Although actual water withdrawals are typically lower than allowed by permit, volumes of water that are withdrawn stress these aquatic systems.

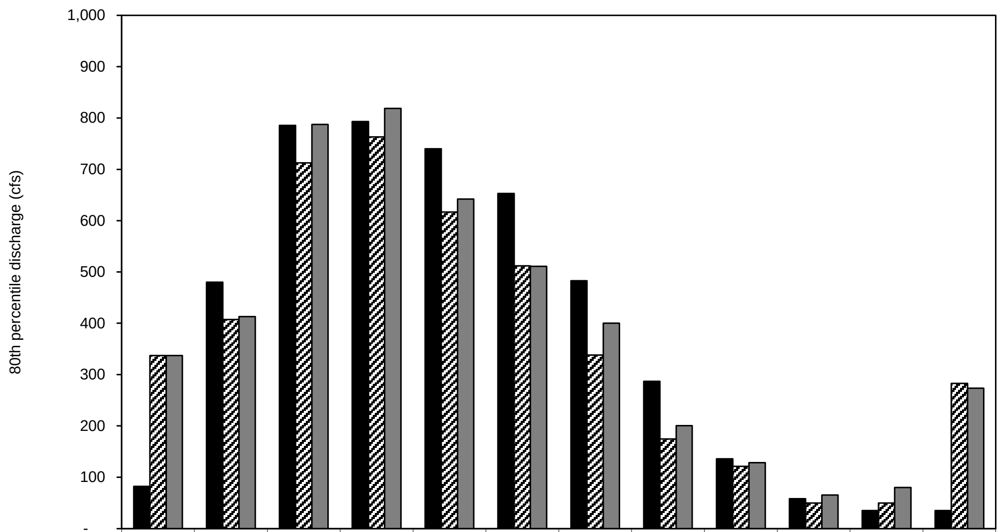
The OWRD water availability process (OAR 690-400-011) has determined that no additional natural flow is available for out-of-stream use from the westside subbasins for periods ranging from 1 to 10 months, depending on the existing level of water development in each subbasin.

USACE dams have diminished flooding and augmented late-season flows in the lower Coast Fork Willamette and Long Tom rivers. These hydrologic effects, and their implications for native anadromous salmonids, are discussed below.

Coast Fork Subbasin

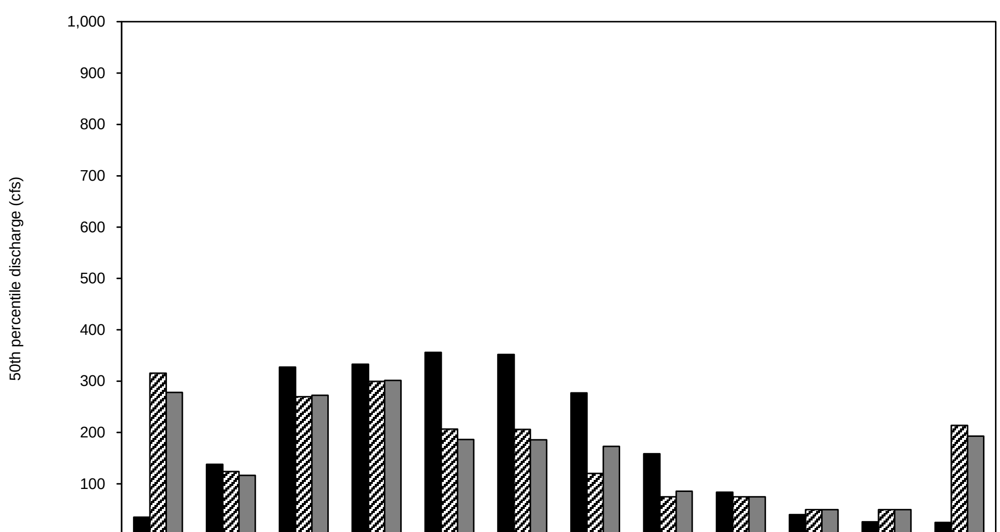
Operation of Dorena and Cottage Grove dams has affected seasonal flow patterns in the lower Coast Fork Willamette River and lower Row River (Figures 4.9-2 and 4.9-3). The greatest project-induced reduction in flow below these dams has been during February; the project lowers median daily flows during that month by about 48% in the lower Coast Fork and by about 41% in the lower Row River. The project has reduced median daily April flows by 38% and increased median daily August flows by 92% in the Coast Fork below Cottage Grove Dam. The project has reduced median daily April flows by 20% and increased median daily August flows by 156% in Row River below Dorena Dam. In both rivers, natural flows are lowest in the summer and early fall, but the USACE stores winter floods, redistributing and releasing water later in the year for the purpose of augmenting flows in the mainstem Willamette River.

Figures 4.9-2 A, B & C Simulated discharge (cfs) of the Coast Fork below Cottage Grove Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



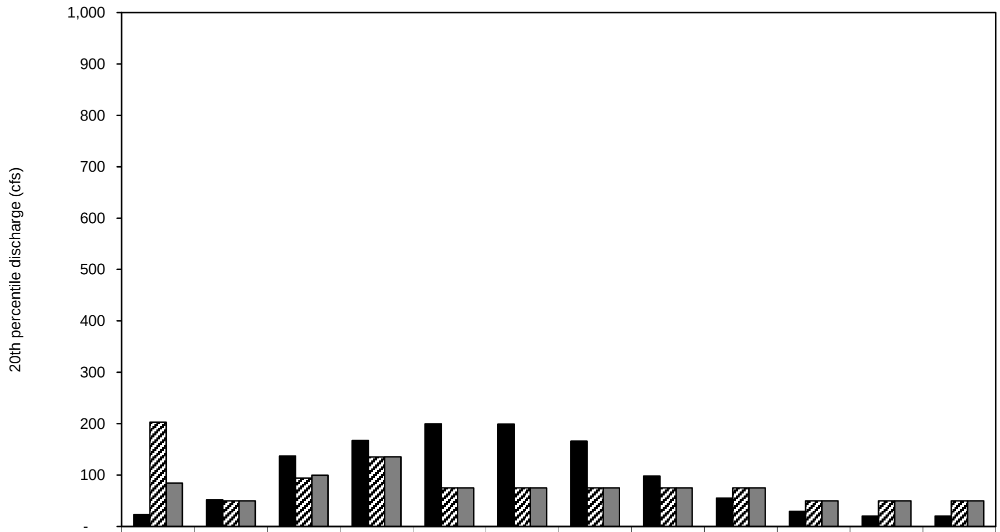
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	82	480	786	793	740	653	483	287	136	58	35	35
Pre-2000	337	407	712	763	617	512	338	175	121	50	50	283
Post-2000	337	413	787	819	642	511	400	200	128	65	80	274

Figure 4.9-2 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	35	138	328	333	356	352	277	159	84	40	26	25
Pre-2000	316	124	270	300	207	206	121	75	75	50	50	214
Post-2000	278	117	273	301	186	186	173	86	75	50	50	193

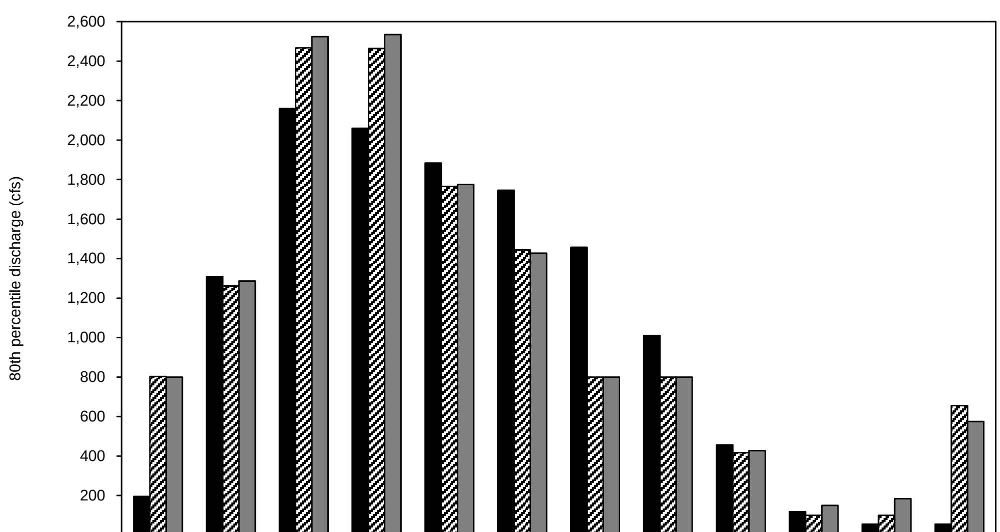
Figure 4.9-2 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	23	52	137	167	200	199	166	98	55	29	20	20
Pre-2000	203	50	94	135	75	75	75	75	75	50	50	50
Post-2000	84	50	100	135	75	75	75	75	75	50	50	50

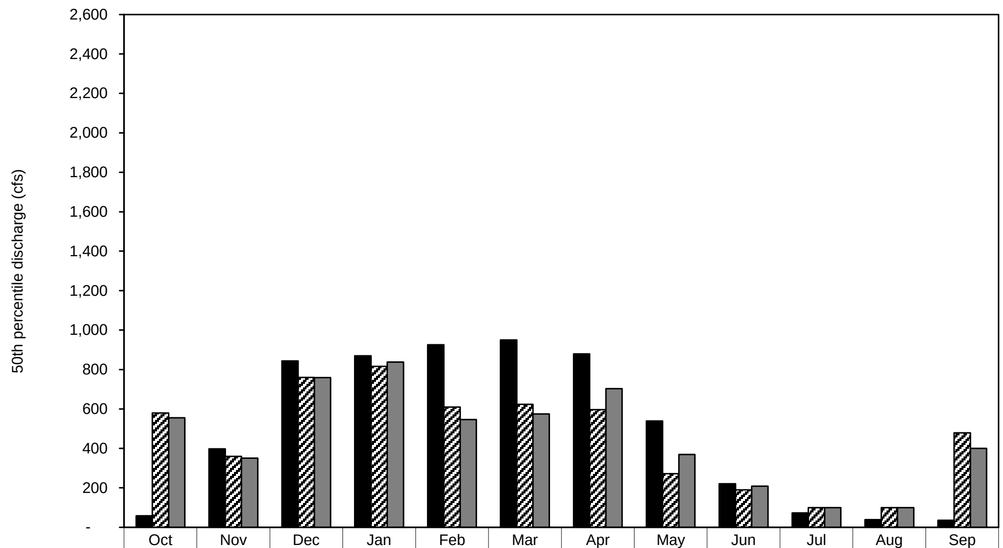
Figure 4.9-2 C

Figures 4.9-3 A, B & C. Simulated discharge (cfs) of Row River below Dorena Dam under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



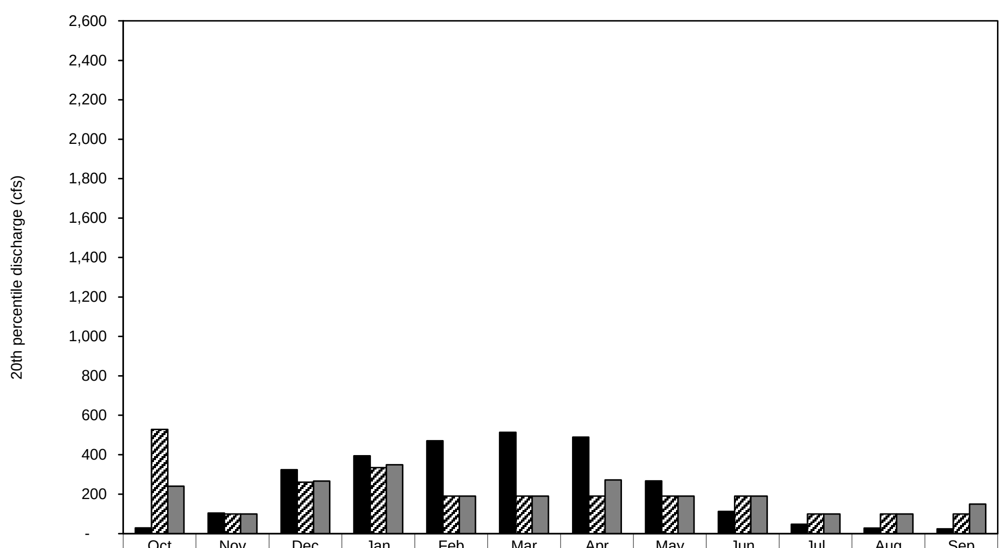
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	196	1,309	2,160	2,060	1,884	1,746	1,457	1,011	457	118	55	55
Pre-2000	803	1,261	2,467	2,464	1,766	1,444	800	800	417	100	100	655
Post-2000	800	1,286	2,524	2,535	1,775	1,427	800	800	428	150	185	575

Figure 4.9-3 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	59	398	844	870	926	950	879	539	221	73	39	35
Pre-2000	580	360	760	816	610	624	597	272	190	100	100	479
Post-2000	556	351	759	838	546	575	703	369	209	100	100	400

Figure 4.9-3 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	29	104	324	394	471	513	489	268	113	48	28	24
Pre-2000	529	100	261	335	190	190	190	190	190	100	100	100
Post-2000	241	100	266	350	190	190	272	190	190	100	100	150

Figure 4.9-3 C

The USACE attempts to release authorized minimum flows at Dorena and Cottage Grove dams. At Dorena Dam these flows are 190 cfs from December through June and 100 cfs from July through November. At Cottage Grove Dam these flows are 75 cfs from December through June and 50 cfs from July through November. Actual flows are below these targets when necessary to reduce downstream flood risk and during other project-related emergencies. The lowest natural daily mean flow recorded at the Goshen gage was 36 cfs in September 1909. Following dam construction, the lowest daily mean flow has been 86 cfs, observed in November 1953.

The Coast Fork supplies water for domestic, industrial, and agricultural uses. The OWRD has issued permits for surface water withdrawals of up to 177 cfs from the Coast Fork Willamette River (OWRD 2003). This is a maximum allowable diversion and actual withdrawals are typically lower than allowed by permit. Due to high water demands downstream, the OWRD water availability process (OAR 690-400-001) has determined that natural flow is not available for out-of-stream use from the Coast Fork Willamette River during February through November. Further, the Willamette Basin Program Classifications (OAR 690-502-0110) require that new surface water users in the subbasin obtain water service contracts from USBR (i.e., for irrigation use of water stored in Willamette Project reservoirs during the summer months). The USBR has issued contracts for a total of 1,272 acre-feet of water stored in Cottage Grove and Dorena reservoirs to be diverted from the Row and Coast Fork Willamette Rivers (USACE 2007a).

Summer streamflows below the USACE dams in the Coast Fork subbasin are higher now than they were before dam construction. Summer is a period of rapid growth for juvenile Chinook salmon, and this increase in flows likely offsets other water diversions and provides some benefit for juvenile Chinook salmon growth and survival. However, with very low use of the Coast Fork watershed by anadromous fish, this benefit would only be realized for fish holding and rearing near the mouth of the Coast Fork Willamette, and possibly in the mainstem Willamette River.

Long Tom Subbasin

Operation of the Fern Ridge project has altered seasonal flow patterns downstream in the Long Tom River (see Figure 4.9-4). The project has reduced average daily April flows by 39% and has increased average daily August flows by 238% at the Monroe gage. Post-project summer flows are generally greater than they were historically because the USACE releases water as required to serve irrigation demand while meeting minimum flow targets in the summer months at Monroe on the Long Tom River. Fern Ridge Reservoir is not drafted to meet instream flow requirements on the mainstem Willamette River during the summer because of its high priority for reservoir recreation.

The USACE attempts to release its authorized minimum flows of 50 cfs from December through June and 30 cfs from July through November. However, the USACE releases flows below these targets when necessary to reduce downstream flood risks and during other emergencies. Prior to dam construction, the lowest flow recorded at Alvadore, Oregon (USGS Station No. 14169000), immediately downstream from Fern Ridge Dam, was 7 cfs during October 1939. The lowest flow recorded since the project was completed was 2 cfs, observed during October 1945. In recent years, discharges have rarely been less than 20 cfs.

The Long Tom River is used extensively to supply water for domestic, industrial, and agricultural activities. The OWRD has issued permits for surface water withdrawals for 331 cfs from the Long Tom River. This is a maximum allowable diversion right and actual diversions are lower at any particular time. The OWRD water availability process (OAR 690-400-011) has determined that natural flow is not available for out-of-stream use from the Long Tom River during August. Further, the Willamette Basin Program Classifications (OAR 690-502-0110) require that new surface water users in the subbasin obtain water service contracts from USBR for irrigation uses of water during summer months. The USBR has issued contracts totaling 24,053 acre-feet of water from Fern Ridge Reservoir to be diverted from the Long Tom River (USACE 2007a).

There is no known anadromous fish reproduction in the Long Tom subbasin. The only known use of the Long Tom River by anadromous fish is occasional use by rearing juveniles when conditions are favorable (fall through spring). By reducing spring flows, the operation of the Fern Ridge project reduces available juvenile rearing habitat during the spring in the Long Tom River. Because such use is small, this adverse effect is estimated to have only a slight effect on UWR Chinook or steelhead.

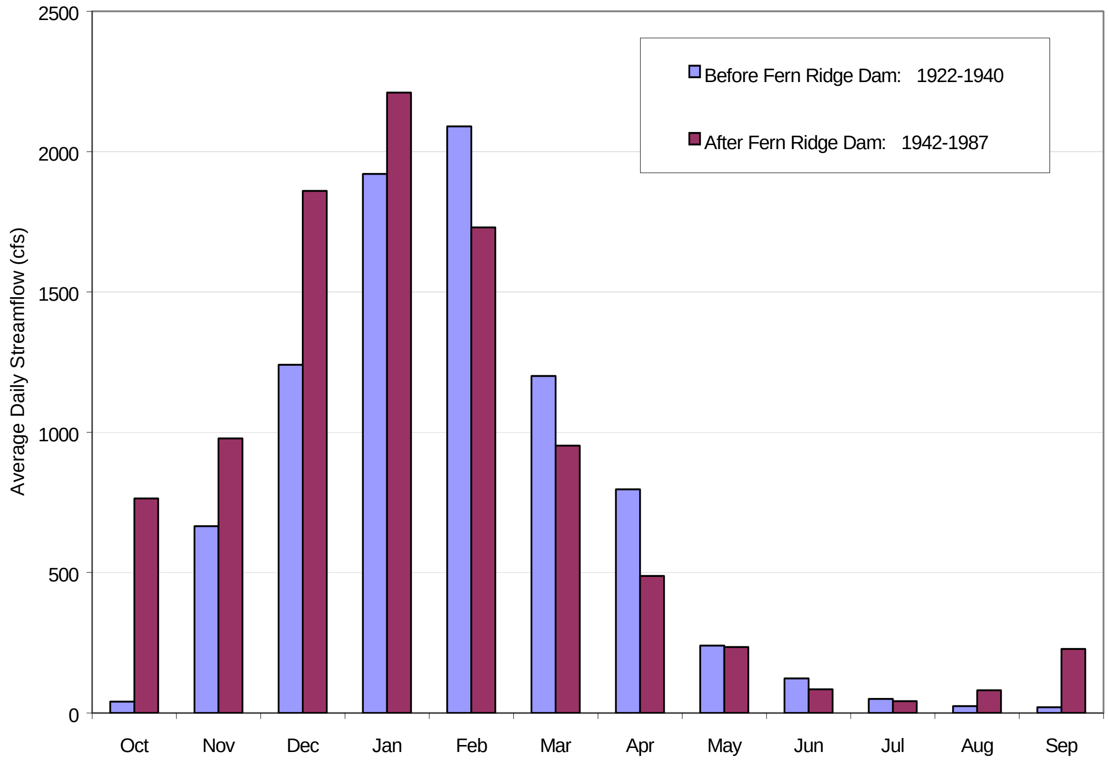


Figure 4.9-4. Mean monthly discharge in the Long Tom River at Monroe (USGS gauge no. 1417000), before (1922-1940) and after (1942-1987) construction of Fern Ridge Dam.

4.9.3.2.1 Peak Flow Reduction

Reductions of natural peak flows can diminish dynamic channel forming processes that are important to creating and maintaining high-quality salmonid habitats in rivers. Project operations have caused such reductions to occur along large river channels in both the Coast Fork and Long Tom subbasins.

Coast Fork Subbasin

Flows in the Coast Fork and Row rivers have been controlled by Dorena and Cottage Grove dams since the 1940s. Flood control operations at the two dams have substantially decreased the magnitude and frequency of extreme high flow events in the lower reaches of the rivers. Flows greater than 15,000 cfs were common in the Row River near Cottage Grove, Oregon before the construction of Dorena Dam (USACE 2000). Since construction, the two-year recurrence interval event has decreased from about 11,100 cfs to about 4,900 cfs, but flows up to 15,000 cfs have occurred on rare occasions. Although the pre-dam flow record below Cottage Grove Dam is not long enough to conduct a similar comparison, the degree of flood flow reduction in that location is probably similar to that observed on the Row River downstream from Dorena Dam.

Reductions in peak flows caused by flood control operations at Cottage Grove and Dorena dams have contributed to a loss of habitat complexity in the lower Coast Fork Willamette River by substantially reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control tends to reduce channel complexity (e.g., reduces the frequency of side channels, and large wood recruitment) and reduces the movement and recruitment of channel substrates. Side channels, backwaters, and instream large wood accumulations have been shown to be important habitat features for rearing juvenile salmonids.

Operation of USACE's Cottage Grove and Dorena dams is only partly responsible for the reduction in channel complexity noted in the lower Coast Fork. Bank stabilization measures and land leveling and development in the basin have directly reduced channel complexity and associated juvenile salmon rearing habitat (see section 4.9.3.4).

Long Tom Subbasin

Fern Ridge Reservoir has regulated flow in the Long Tom River since 1941. Flood control operations at Fern Ridge Dam have decreased the magnitude and frequency of extreme flow events, although the overall reduction has been relatively small compared to that caused by other Willamette Basin projects. The highest flow on record at Monroe, Oregon (USGS Station No.14170000), 19,300 cfs, occurred in 1943, 2 years after Fern Ridge was completed (USACE 2000). Operation of Fern Ridge Dam has reduced magnitude of the 2-year recurrence interval flood event from greater than 8,000 to less than 5,000 cfs (see Figure F-27 in USACE 2000).

Reductions in peak flows have contributed to a loss of habitat complexity in the lower Long Tom River by reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. However, virtually the entire reach of the Long Tom River has been channelized, straightened, leveed, or otherwise modified by projects related to drainage and irrigation (Thieman 2000).

At the time of construction, maintaining channel complexity for anadromous fish was considered a minor concern along the lower Long Tom River because the system did not appear to support either migratory or resident salmonids (U.S. Engineer Office 1939; Craig and Townsend 1946). However, ODFW caught yearling Chinook in a screw trap in the lower Long Tom River (about 7 miles from the Willamette) in recent years, indicating that this area may be used as winter rearing habitat (Schroeder and Kenaston 2004).

4.9.3.2.3 Effects of Seasonal Flow Patterns on Spawning Success

Native anadromous salmonids are not known to spawn at present in the Coast Fork below Cottage Grove Dam nor in Row River below Dorena dams, and it seems unlikely that they have ever spawned in the Long Tom River above or below Fern Ridge Dam. If the offspring of adult UWR Chinook outplanted into Mosby Creek were to return as adults and spawn below Dorena Dam on the Row River, flows that are greatly elevated by reservoir drafting operations during the September-October spawning period may encourage fish to use areas near the channel margins that could become dewatered during periodic flood-control operations during late fall and winter. Chinook embryos incubating in redds constructed along the channel margins would thus be at risk of mortality due to dewatering. However, although there are no data available regarding adult returns from the Mosby Creek outplanting effort, it is likely that most returns would spawn in Mosby Creek rather than in the mainstem Row River below Dorena Dam.

4.9.3.2.4 Flow Fluctuations, Entrapment, and Stranding

Rapid fluctuations in flow levels below hydropower or flood control dams have the potential to kill young salmonids by trapping and stranding them on exposed riverbed surfaces. Such risks are present below USACE dams in the Coast Fork and Long Tom subbasins during major storm events in late fall through winter, when flows below the dams can drop quickly in order to reduce the potential for flooding downstream along the mainstem Willamette River.

Coast Fork Subbasin

There are currently no powerhouses at the Dorena or Cottage Grove projects. Symbiotics LLC has proposed to install turbines and a powerhouse at Dorena Dam, but this proposal would not alter operations. (Symbiotics 2004). Rapid fluctuations in discharge would occur only during flood control or other emergency operations. The USACE currently operates both the Dorena and Cottage Grove projects with no limit on the rate of discharge reduction during high flow conditions. Under low flows the downramping rate is 200 cfs per hour and 500 cfs per day at Dorena Dam and 100 cfs per hour at Cottage Grove. No specific studies have been conducted documenting the effects of downramping at Dorena or Cottage Grove dams. With little current or future expected use of the Coast Fork Willamette River by spring Chinook, these issues may be of limited consequence for the recovery of ESA-listed anadromous salmonids in the Willamette Basin.

Long Tom Subbasin

There is no powerhouse at the Fern Ridge project. Rapid fluctuations in discharge would occur only during flood control or some other emergency operation. The USACE currently operates the Fern Ridge project to limit the rate of change in discharge (increasing and decreasing) to 200 cfs per hour during low flows, and during high flows, tries to limit upramping to 750 cfs per hour with a maximum rate of 1,000 cfs per hour. There is no limit on downramping rates during high flows.

The principal risk that flow fluctuations pose for anadromous salmonids is the potential for entrapment and stranding of rearing juveniles during rapid winter down-ramping operations. UWR Chinook salmon are known to rear in the lower 7.6 miles of the Long Tom River and may be affected by ramping at Fern Ridge, though no data are available to document the frequency or severity of this potential effect.

4.9.3.3 Water Quality

Water quality is impaired in many streams within the Willamette's westside subbasins, particularly in lowland areas affected by agricultural, rural-residential, and urban development. Much of the Willamette River's non-point source pollution originates within these subbasins. Common water quality problems found within them include elevated temperatures, increased nutrient concentrations (particularly phosphorous), bacterial contamination, and lowered levels of dissolved oxygen. In the Coast Fork subbasin, mercury is also a problem. TMDLs and associated Water Quality Management Plans have been developed to address these problems.

The following sections discuss water quality conditions specific to the Coast Fork and Long Tom subbasins, in areas where Willamette Project dams may affect ESA-listed salmonids. Mercury contamination in the Coast Fork and Row River below USACE dams has the potential to affect the health of fish residing in those waterways and make re-establishing self-sustaining anadromous salmonid populations in those rivers difficult.

4.9.3.3.1 Water Temperature

Warm summer temperatures are a chronic problem in many streams within the westside subbasins. This problem appears reduced in the lower Coast Fork and Row rivers by Project dams that then elevate river temperatures during fall in ways that would be unfavorable for naturally spawning UWR Chinook if present. Warming that occurs in Fern Ridge Reservoir may warm summer temperatures in the lower Long Tom River.

Coast Fork Subbasin

The ODEQ 2004/2006 Integrated Report Database indicates that summer water temperatures are warmer than criteria for salmonid rearing and migration in the Coast Fork Willamette and Row rivers below Cottage Grove and Dorena dams. Exceedences have also been reported in some unregulated reaches within the subbasin (i.e., not affected by Willamette Project flow management). A TMDL for the Willamette Basin was approved for temperature in 2006 (ODEQ 2006a). In that TMDL, ODEQ identified target temperatures for releases below Cottage Grove and Dorena dams, based on the seasonal temperature patterns of water entering the reservoirs immediately upstream (Table 4.9-2).

Table 4.9-2 Monthly rolling average of 7-day median temperatures downstream of Cottage Grove and Dorena dams, and established ODEQ monthly target temperatures (ODEQ 2006a, Chapter 4). No data presented for December through March; allocations/targets were not determined necessary for November through March.

Month	Cottage Grove Release Temperatures	ODEQ Target for Cottage Grove Releases	Dorena Release Temperature	ODEQ Target for Dorena Releases
April	9.5	9.4	8.8	8.8
May	10.4	11.4	10.2	10.8
June	11.9	15.5	11.1	16.5
July	13.7	19.9	13.3	22.3
August	17.1	18.3	13.2	20.4
September	19.5	16.4	14.1	18.2
October	15.5	13.5	16.2	15.3
November	10.6	--	10.3	--

As illustrated in Table 4.9-2 (above), both Cottage Grove and Dorena dams modify natural temperature patterns in downstream reaches. These modifications include cooler summer water temperatures (Jun-Aug) and warmer fall water temperatures (September-October). Cooler summer temperatures make the rivers below the dams more hospitable for juvenile salmonid rearing at that time of year. Elevated temperatures during September and October make the rivers less suitable for use by spring Chinook by lowering egg survival rates, accelerating the development of any embryos incubating in riverbed gravels, and causing fry to emerge earlier than is optimal for survival and growth.

Long Tom Subbasin

According to the ODEQ's 2002 CWA section 303(d) database, 98% (41/42) of the summer temperature measurements taken at RM 4.7 in the Long Tom River exceeded maxima for salmonid rearing and migration (17.7°C; 64°F) during the period 1986 through 1995 (ODEQ 2002). The maximum measured value was 29°C (84.2°F), which can be lethal to juvenile salmonids (Appendix A, Table A-2). The ODEQ listed the entire mainstem Long Tom below Fern Ridge Dam as water quality-limited for temperature. The Long Tom Watershed Council (Thieman 2000) reported that 36% of 45 temperature measurements collected in the reach below Fern Ridge Dam during the 1990s exceeded summer maxima for non-core rearing and juvenile and adult migration (64°F), a status the LTWC considered "moderately impaired." During winter, when temperatures are below the maximum for rearing, the ODFW has captured juvenile spring Chinook in a screw trap in the lower Long Tom near Monroe (Kenaston 2003). These fish probably rear in the lower Long Tom before emigrating from the system the following spring.

High water temperatures are likely to preclude juvenile Chinook from rearing in the lower Long Tom River during summer. The Thieman (2000) reported that water temperature conditions in tributaries to Fern Ridge Reservoir were "moderately impaired" and that Fern Ridge Reservoir itself was "impaired." Given the reservoir's shallow depth, and the residence time of water within the reservoir, it is possible that USACE operations at Fern Ridge are responsible for elevated temperatures in the lower Long Tom River.

4.9.3.3.2 Dissolved Oxygen

Dissolved oxygen levels were once an issue in the lower reaches of many lowland streams in the westside subbasins, and remain so in some of them today. Within the Coast Fork and Long Tom subbasins, flows augmented by Project reservoirs have helped reduce such problems in the lower Coast Fork and Long Tom rivers.

Coast Fork Subbasin

In July and August 1994, the USGS documented the spatial extent and daily variability of dissolved oxygen concentrations in selected reaches of the upper Willamette River basin (Pogue and Anderson 1995). Results of the study indicated that the Coast Fork Willamette River from RMs 21.7 to 12.5 had dissolved oxygen concentrations that fluctuated below ODEQ's numerical criteria, presumably due to the breakdown of treated sewage effluent. The ODEQ 2004/2006 Integrated Report database confirms that the Coast Fork below Cottage Grove Dam continues to experience dissolved oxygen conditions that do not fully support salmon and steelhead spawning but that will support other river uses by cold-water aquatic life (ODEQ 2006b). A TMDL was approved in 1996 for this reach.

Dissolved oxygen is known to fall below desirable concentrations in the lower levels of Dorena Reservoir, but there are few records of low dissolved oxygen occurring in Row River below Dorena Dam. When monitored during 2003 and 2004, dissolved oxygen concentrations dropped below ODEQ's absolute minimum of 6.5 mg/L for cold water habitat in the bottom waters of the reservoir in July or August, but not in the river downstream (Symbiotics 2006). Water is aerated as it is released from the dam through the existing outlet gates, resulting in DO levels ranging from just below 10 to over 12 mg/L below the dam.

ODEQ maintains a Row River monitoring site 5 miles downstream of Dorena Dam. The ODEQ 2004/2006 Integrated Report database indicates that at this site, 1 out of 16 samples did not meet DO criteria for cold-water aquatic life (i.e., too DO low); and 0 out of 3 samples did not meet the criteria for spawning anadromous and resident fish (ODEQ 2006b). Insufficient data is currently available to develop a TMDL for this reach.

Long Tom Subbasin

High summer water temperatures documented in the lower Long Tom River reflect watershed conditions that might be expected to contribute periodically to low dissolved oxygen concentrations in this subbasin's streams. The Long Tom Watershed Council (Thieman 2000) reports that dissolved oxygen concentrations ranged from 7 to 13 mg/L in 45 water samples collected from the river below Fern Ridge Dam during the 1990s, suggesting that conditions in the lower river do occasionally fall below levels desirable for cold-water organisms. However, ODEQ's 2002 CWA section 303(d) list of impaired waterbodies does not identify any streams in the Long Tom watershed that are water quality limited due to low dissolved oxygen concentrations (ODEQ 2002).

4.9.3.3.3 Total Dissolved Gas

High total concentrations of dissolved gases (TDG) are generally not a water quality problem found in most of the westside tributaries, but they have been found below some Project dams in the Willamette Basin. Available information on occurrences of high TDG levels associated with USACE dams in the Coast Fork and Long Tom subbasins is given below.

Coast Fork Subbasin

The ODEQ 2004/2006 Integrated Report database does not identify any streams in the Coast Fork Willamette subbasin that are water quality limited due to high TDG concentrations (ODEQ 2006b). However, Symbiotics (2005) measured TDG in the deep bottom waters of Dorena Reservoir as well as in the Row River just below the existing outlet gates at Dorena Dam. TDG levels deep in the reservoir exceeded ODEQ's 110% maximum saturation standard during February and March. Symbiotics also concluded that aeration through the dam's outlet gates causes TDG below the dam to exceed DEQ's standard in July and August. There are no other data on TDG concentrations in areas of the Coast Fork Willamette subbasin used by listed anadromous salmonids.

Long Tom Subbasin

The ODEQ's 2002 CWA section 303(d) list does not identify any streams in the Long Tom watershed are water quality limited due to excessive amounts of total dissolved gas (ODEQ 2002).

4.9.3.3.4 Nutrients

Elevated nutrient levels are a common problem in lowland streams within westside subbasins, though less so in the Coast Fork subbasin due to relatively higher proportions of forestlands and public ownership in that area. Project dams may have reduced (but not eliminated) the potential for lowland development to cause such problems along the lower mainstem reaches of the Coast Fork and Long Tom subbasins by augmenting summer flows.

Coast Fork Subbasin

The lower Coast Fork of the Willamette River, from Cottage Grove Dam to the mouth, had a TMDL for phosphorous approved in March 1995.

Long Tom Subbasin

The Thieman (2000) reported that nearly all (98%) of 43 water samples ODEQ collected from the Long Tom River below Fern Ridge Dam during the 1990s had total phosphorus concentrations that exceeded 0.05 mg/L, a condition described as "impaired." The ODEQ has not set a numerical criterion for total phosphorus in the Long Tom subbasin.

4.9.3.3.5 Turbidity

Coast Fork Subbasin

The ODEQ 2004/2006 Integrated Report database does not indicate that any streams in the Coast Fork Willamette subbasin are water quality limited due to excess turbidity.

Long Tom Subbasin
The Long Tom River downstream of Fern Ridge Dam is generally described as turbid (Ely 1981; McIntosh et al. 1995). Thieman (2000) reported that only 5% of 41 turbidity measurements in the reach below Fern Ridge Dam during the 1990s had turbidity levels that exceeded 50 NTU. However, 16% of the total dissolved solids measurements exceeded 100 mg/L, a condition which was described in the watershed assessment as “moderately impaired.”

4.9.3.3.6 Toxics
Toxic substances are a concern in both the Coast Fork and Long Tom subbbasins. Mercury contamination is of particular concern in the Coast Fork subbasin and pesticides are a concern in the Long Tom subbasin.

Coast Fork Subbasin
Mineral-bearing intrusive dikes are common in the headwaters of the Row River, an area that continues to be mined both commercially and recreationally. Mercury has been mined intensively in the Black Butte area, located in the upper Coast Fork drainage, which has been the most productive mining district in the Oregon Cascades for gold, silver, copper, lead, zinc, and antimony (USACE 2000). Mercury has been found in fish from Cottage Grove and Dorena reservoirs at levels potentially hazardous to humans. The highest mercury loadings are typically seen in large resident fish that prey on other fish, including bass, northern pikeminnow, and large trout. Both lakes have fishing regulations that are aimed at limiting the consumption of these fish. Mercury probably enters Dorena and Cottage Grove reservoirs as a result of mining and natural sources higher up in the watershed, but the relative contribution of mining compared to natural inputs from soils, volcanic rocks, and geothermal water sources is unknown. Park and Curtis (1997) indicated that a point source, Black Butte Mine, resulted in mercury concentrations in Cottage Grove Reservoir that are higher than would be expected from natural (background) sources, atmospheric deposition, and use of the metal during processing of gold.

The ODFW reared juvenile spring Chinook salmon in Cottage Grove Reservoir during 1969 through 1976, but the resulting smolts were believed to have low survival upon entering salt water as a result of accumulated mercury (ODFW 1990c). High mercury levels have also been found in several fish species collected throughout the length of the mainstem Coast Fork Willamette River. The ODEQ 2004/2006 Integrated Report database listed the mainstem Coast Fork reach from the mouth to RM 38.8 (including Cottage Grove Reservoir) and the Row River from its mouth to RM 20.8 (including Dorena Reservoir) as impaired for anadromous fish passage, resident fish, aquatic life, and human health due to mercury contamination (ODEQ 2006a). A TMDL for mercury was approved in 2006.

Long Tom Subbasin
Fourteen pesticides were detected at a site on the Long Tom River near Bundy Bridge, at RM 1, during four sampling periods in 1994 (Rinella and Janet 1998). Compared to the streams that USGS sampled, this site had the highest number and concentrations of pesticides (Thieman 2000). The EPA has recommended a numerical criterion for the protection of aquatic life for one of the 14 compounds, chlorpyrifos (0.04 μg/L), and the highest concentration detected in the Long Tom samples was much lower (0.009 μg/L). The fact that the pesticide data are based on only four sampling periods makes it difficult to draw any conclusions about the overall impact of pesticides on water quality in this subbasin (Thieman 2000).

4.9.3.4 Physical Habitat Characteristics

Changes to aquatic habitats within the westside subbasins have affected the productivity, capacity, and diversity of their salmonid populations, including Chinook salmon, steelhead, and resident salmonids (WRI 2004), and the magnitude of these changes has been considerable in many areas. However, many of the changes that have occurred in these subbasins are peripheral to an assessment of the influence of the Willamette Project and its various programs on the future viability of UWR Chinook and UWR Steelhead. The following discussion of baseline habitat conditions within these subbasins will therefore be somewhat less detailed than have earlier discussions of habitat in eastside subbasins, and will focus primarily on those subbasins in which the USACE operates dams: the Coast Fork and Long Tom.

As elsewhere in the Willamette Basin, adverse human effects on the physical characteristics of salmonid habitat tend to be more pronounced in lowland portions of the westside subbasins than they are in the forested uplands. This pattern is attributable to differing land-use histories, uneven levels of land-use regulation, and cumulative effects that tend to increase in the downstream direction.

4.9.3.4.1 Substrate

Historical splash-damming, active removals of large wood, intentional channel alterations, and increased rates of fine sediment delivery to streams caused by chronic land disturbances, have affected the stability and composition of streambed sediments in westside subbasins. These changes have likely diminished aquatic productivity and the quantity and quality of spawning gravels available to salmonids in the areas affected. Within the Coast Fork and Long Tom subbasins, USACE dams are also playing a role in the movement of sediment to and through streams. Coarse sediments once transported from the upper to lower portions of the drainage networks in these two subbasins are now trapped in reservoirs above USACE dams.

Coast Fork Subbasin

All coarse sediment from approximately 54% of the 680 square mile Coast Fork subbasin is trapped behind Cottage Grove Dam and Dorena Dams (USACE 2000), creating a sediment starved system in the Row and Coast Fork Willamette rivers downstream of the dams. This problem has been exacerbated by gravel mining in these reaches, further reducing sediment supply (BLME 1995b). The result has likely been a coarsening of the riverbeds downstream of the dams (USACE 2000) and a reduction in substrate diversity and spawning areas for salmonids.

Long Tom Subbasin

Construction of Fern Ridge Dam blocked the downstream transport of sediment from over 60% of the Long Tom subbasin and left the lower Long Tom River dependent on tributaries or the erosion of its channel as sources of sediment. The river’s tributaries appear to be less than prolific sources of coarse sediment, leaving channel erosion as a likely response to the reduction in sediment supply (USACE 2000). Three small concrete dams have been constructed in the lower Long Tom River to control degradation of the riverbed.

Only two small tributaries within the Long Tom watershed (Ferguson and Bear Creeks) have been extensively surveyed, but surveys of these streams revealed elevated sand and silt content in each reach surveyed.

4.9.3.4.2 Large Woody Debris

Stream cleaning practices and past management of riparian areas have substantially reduced in-channel wood and the potential for natural recruitment of large wood to streams within the westside subbasins. The loss of in-channel wood has reduced the quality of salmonid habitat present by modifying gravel deposition patterns, reducing the frequency and depth of pools, and limiting the availability of hiding cover for adult and juvenile fish (WRI 2004). Such habitat deficiencies tend to be most pervasive and severe in valley floor settings where extensive agricultural, rural-residential, and urban development have removed or altered much of the vegetation once found on streambanks or floodplains. Given low potentials for natural wood recruitment, the prognosis for substantial near-term improvements in this situation without active intervention is poor.

Levels of large wood in streams and riparian corridors within the Coast Fork and Long Tom subbasins are as just described for westside subbasins as a group, with the exception that (federal) land in the upper Coast Fork subbasin is managed with a stronger conservation emphasis than is found across most of the Willamette Basin’s westside. Additionally, reservoirs behind the USACE dams in these two subbasins function as woody debris traps, eliminating the transport of large wood from upper to lower portions of the watersheds within which they have been constructed. This has left the lower Coast Fork, Row, and Long Tom rivers entirely dependent on the diminished wood resources available along their banks, floodplains, and tributaries to help create or maintain the pools, side channels, debris jams, and near-bank cover that are important features of good salmonid habitat.

Coast Fork Subbasin

Abundances of large wood in streams channels within the Coast Fork subbasin above Dorena and Cottage Grove Dams, and prospects for natural recruitment of additional wood to those channels, have been characterized by BLME (1995b, 1997, and 1999) and WRI (2004). Many streams in the upper Coast Fork and Row River drainages lack large wood, large pools, and the high-quality rearing areas generally associated with high wood abundance (BLME 1995b, 1997).

Most large wood that enters Dorena and Cottage Grove Dams is removed from the river system. This leaves the lower Coast Fork and Row rivers dependent on wood that might be recruited naturally from areas where most potential riparian or floodplain sources of such wood have been depleted by a variety of human activities such as clearing for agriculture and urban development, road construction, and timber harvest.

Long Tom Subbasin

Historical accounts of the Long Tom River describe large quantities of in-channel wood that made navigation difficult and that persisted for a period of time despite USACE efforts to remove obstructions from the river (Thieman 2000). This is no longer the case. Splash damming, stream cleaning, removal of riparian forests, and channelization of the lower river by the USACE have diminished both in-channel wood and the potential for recruitment of new large wood to the system. Today, many miles of streams within the subbasin have lost the structural complexity associated with abundant in-channel wood (WRI 2004) and riparian forests in both the upper and lower portions of the system are not capable of producing large wood at levels comparable to their historical capacity (Thieman 2000). The result along the lower Long Tom River, below Fern Ridge Dam, has been a wood-depleted reach with salmonid habitat of substantially lower than historical quality.

4.9.3.4.3 Channel Complexity, Off-channel Habitat & Floodplain Connectivity

Throughout the westside subbasins, the consequence of more than a century of watershed development has been a notable reduction in stream channel complexity, off-channel habitats, and the degree of interaction between streams and their floodplains (WRI 2004). These changes have tended to be of greater magnitude in lowland than in upland channels, and have diminished the abundance, productivity, and diversity of salmonid populations (WRI 2004).

Losses of stream complexity within the Coast Fork and Long Tom subbasins have followed the pattern seen in the Willamette's other westside tributary systems, though conservation-focused management on federal forests in upper portions of the Coast Fork subbasin increases prospects for habitat recovery in that area. In both of these subbasins, USACE dams and revetments have been central to losses of habitat complexity along lowland river channels.

Coast Fork Subbasin

Active wood removals, alterations of bottomland forests, dam-caused reductions in wood and sediment delivery, and constraints that revetments and flood control have imposed on river-floodplain interactions, have impaired natural processes that create and maintain complex, high-quality salmonid habitats in the lower Coast Fork and Row rivers. As a result, channel complexity has been reduced and salmonid habitat diminished. USACE revetments that have contributed to this loss include five miles of structures built along the banks of the lower Coast Fork to protect agricultural development from flood damage, and another mile of revetments along the lower Row River (USACE 2000).

As noted above in section 4.9.2.1, Middle Fork Willamette Chinook salmon may use lower reaches of the Coast Fork for juvenile overwintering rearing. Thus, reduced habitat complexity and diminished availability of backwaters or floodplain refugia along lowland channels in the Coast Fork subbasin have the potential to reduce habitat availability for a small number of individual fish each year. This loss is likely to result in a small incremental decrease in abundance and productivity of Middle Fork Willamette Chinook salmon.

Long Tom Subbasin

Flooding remained a problem for Long Tom residents even after construction of Fern Ridge Dam, so the USACE constructed a levee on both sides of the Long Tom River from Fern Ridge Dam to the mouth, installed rip-rap revetments to minimize bank erosion, and added culverts to drain adjacent farmland. Later, the USACE constructed check dams to prevent down-cutting associated with the increased transport capacity of the straightened channel, and re-positioned the confluence of the Long Tom and Willamette rivers. The lower Long Tom River now has a highly simplified channel network and is cut off from side channels and floodplain areas that once provided quality rearing habitat and off-channel flood refugia for rearing juvenile Chinook and steelhead in winter months. Prospects for habitat improvement along the lower Long Tom without active intervention are low given the severity of channel alteration, reduced sediment supply, and limited inputs of large wood. Severe habitat simplification has also occurred along multiple stream channels in the Amazon Creek watershed, tributary to the lower Long Tom River, as a consequence of flood protection efforts in and around the City of Eugene (Thieman 2000).

Simplification of lowland channels in the Long Tom subbasin has reduced their value as seasonal (fall-winter) rearing areas for UWR Chinook and UWR steelhead juveniles. This has the potential to reduce habitat availability for a small number of individual fish each year. This loss is likely to result in a small decrease in abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations of these fish.

4.9.3.4.4 Riparian Reserves & Disturbance History

Riparian vegetation has been altered along most streams within the westside subbasins (WRI 2004). The severity of these alterations has generally been greater along lowland than upland stream channels, a pattern that is evident in both the Coast Fork and Long Tom subbasins.

Coast Fork Subbasin

In upper portions of the Coast Fork subbasin, timber harvest and road construction have reduced riparian vegetation. Recent channel surveys indicate that riparian vegetation in most of these forestlands is less than 60 years old, and that one third of the riparian areas are dominated by alder or other hardwoods rather than conifers. The majority of streams in the upper subbasin do not have riparian trees capable of recruiting adequate large wood to the stream.

In lower portions of this subbasin, losses of riparian vegetation and function have been substantial. For example, recent analyses by ODEQ (2006a) suggest that streamside trees along the lower Coast Fork are currently providing only 64% of site potential shade, and those along the lower Row Rivers are providing only 44%. USACE’s construction of five miles of revetments along the banks of the lower Coast Fork to protect agricultural development from flood damage, and another mile of revetments along the lower Row River (USACE 2000), have contributed to such losses of function.

Long Tom Subbasin

Thieman (2000) has quantified extensive changes that have occurred in riparian communities within the Long Tom subbasin since settlement by examining the losses of ecological function associated with altered spatial distributions and extents of each vegetation type. In many upland areas, deciduous trees now dominate riparian stands that historically contained conifers, primarily due to timber harvesting. In the subbasin’s lowlands, nearly 50% of the original bottomland forests along streams are gone and about 20% have experienced a moderate loss of function associated with shifts to young trees and a very narrow width of riparian forest. Additionally, about 200 miles of the subbasin’s riparian areas are now dominated by shrubland although this vegetation type occupied only 12 miles of riparian area prior to settlement.

A high proportion of the riparian forests within the Long Tom subbasin are not currently capable of producing large wood at levels comparable to their historical capacity, and many do not provide desirable levels of stream shade. Substantial losses of ecological function along approximately 70% of the lowland channels once bordered by bottomland forest reflect a situation in which channels like that of the lower Long Tom River have limited near-term prospects for large wood recruitment. Analyses by ODEQ (2006a) suggest that vegetation along the lower Long Tom River now provides only 44% of site potential shade.

4.9.4 Hatchery Programs

There are no salmon or steelhead hatcheries operating within the westside subbasins, though salmon and steelhead of hatchery origin have been released into these subbasins at various times and locations in the past. Adult UWR Chinook of hatchery origin are currently being released into Mosby Creek in the Coast Fork subbasin in an effort to restart natural production in that area (Moberly 2008). Adult hatchery-origin summer steelhead stray from hatchery programs in eastside subbasins and spawn in streams within the Coast Fork subbasin (Schroeder et al. 2006) and perhaps others.

4.9.5 Fisheries

Naturally produced adult UWR Chinook are not generally found in westside subbasins, but adult UWR steelhead are apparently present in the Tualatin and Yamhill subbasins. Harvest of non-adipose fin-clipped Chinook salmon or steelhead is prohibited in the Willamette Basin (ODFW 2008c); unmarked fish incidentally caught must be released unharmed.

4.9.6 Status of Critical Habitat in Coast Fork Willamette & Long Tom Subbasins

NMFS did not designate critical habitat in the Coast Fork Willamette or Long Tom subbasins because of its relatively low importance to recovery for either UWR Chinook or UWR steelhead.

Table 4.9-3 Habitat elements and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the Coast Fork Willamette and Long Tom subbasins under the environmental baseline.

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat access	Physical barriers	*Coast Fork subbasin:* Dorena Dam blocks Chinook salmon access to historical habitat, however, the W/LC TRT does not believe this habitat supported a demographically independent population No human-made barriers limit the viability of a demographically independent population *Long Tom subbasin:* Three small USACE check-dams on the Long Tom below Fern Ridge Dam that may limit juvenile fish access to historical rearing areas.	N/A USACE
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/Hydrology)	Change in peak/base flow	*Coast Fork and Long Tom subbasins:* Frequency of channel-forming flows not of sufficient magnitude to create and maintain channel complexity and provide nutrients, organic matter, and sediment inputs from floodplain areas Increased summer flows may increase rearing area and the heat capacity of the stream Low streamflow conditions are affected by water development and reservoir operations Flow fluctuations now occur at rates rapid enough to entrap and strand juvenile anadromous fish.	Flood control operations at USACE's dams reduce the magnitude and frequency of peak flows Flow augmentation from USACE reservoirs to meet mainstem flow targets Summer diversions for out-of-stream use Flood control operations at USACE dams cause rapid flow reductions

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	*<u>Coast Fork subbasin</u>:* The ODEQ 2004/2006 Integrated Report database indicates exceedances of temperature criteria (18C) for rearing and migration of salmon and trout for reaches below Cottage Grove and Dorena dams during summer and early fall. A temperature TMDL was approved for these and other areas of the Willamette Basin in 2006. Exceedances have also been reported in some unregulated reaches for both spawning and non-spawning periods (i.e., not affected by Willamette Project flow management). *<u>Long Tom subbasin</u>:* ODEQ 2002 CWA 303(d) database indicates that 98% of summer temperature measurements at RM 4.7 exceeded maxima for core rearing (16C) and non-core rearing and adult and juvenile migration (18C) during the period 1986 through 1995. Temperatures high enough to be lethal or nearly so to juvenile salmonids have been measured during summer. Juvenile Chinook occupy the lower Long Tom during winter, when temperatures are below maxima	USACE operations (Cottage Grove and Dorena dams) Water diversions and return flows Loss of riparian vegetation for shading Clearing for floodplain development USACE operations (Fern Ridge Dam) Timber harvest (upper subbasin) Livestock operations

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/Turbidity	*Coast Fork subbasin*: The ODEQ 2004/2006 Integrated Report database does not report any streams as water quality limited due to excess turbidity *Long Tom subbasin*: 5% of 41 turbidity measurements below Fern Ridge Dam during the 1990s had levels that exceeded 50 NTU, described as "impaired" 16% of total dissolved solids measurements exceeded 100 mg/L, described as "moderately impaired"	N/A Streambank erosion due to grazing Agriculture Timber harvest (upper watershed) Road construction and maintenance

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/Nutrients	<u>*Coast Fork subbasin*</u>*:* The ODEQ 2004/2006 Integrated Report database lists the mainstem Coast Fork Willamette River from the mouth to RM 31.3, Cottage Grove Reservoir, the Row River from RM 0 to 20.8, and Dorena Reservoir, as impaired for aquatic life, due to mercury contamination from mining activities in the upper drainage. The ODEQ 2004/2006 Integrated Report database listed the mainstem Coast Fork below and including Cottage Grove Reservoir) as impaired for aquatic life due to increased iron concentrations (ODEQ 2006a). The ODEQ 2004/2006 Integrated Report does not identify any streams are water quality limited due to excess nutrients. However, occurred during low-flow periods on the Row River below Dorena Dam (the ODEQ OWQIR (1986-1995)) (Cude 1996a). <u>*Long Tom subbasin*</u>*:* 98% of 43 water samples collected below Fern Ridge Dam during the 1990s had total phosphorus concentrations that exceeded 0.05 mg/L, a condition described as "impaired" per GWEB recommendations Fourteen pesticides were detected at a site near Bundy Bridge (Long Tom RM 1) during four sampling periods in 1994	Mining City of Creswell's sewage treatment plant, agriculture, nursery operations, logging operations (ODEQ WQ Index Report (1986-1995) (Cude 1996a). Agriculture Rural development (fertilizers) Agriculture Transportation Rural development

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	<u>*Coast Fork subbasin*</u>: The ODEQ 2004/2006 Integrated Report database indicates that areas below Cottage Grove Dam is limited for salmon and steelhead spawning; but attaining some criteria for cold-water aquatic life The ODEQ 2004/2006 Integrated Report database indicates that on the Row River 1 out of 16 samples exceeded criteria for cold-water aquatic life; and 0 out of 3 sample exceeded criteria for spawning anadromous and resident fish. In August 2003 and July 2004, DO measured in Dorena Reservoir bottom waters dropped below 6.5 mg/L. Water is aerated as it is released through the existing outlet gates, resulting in higher DO levels below the dam (Symbiotics 2005) <u>*Long Tom subbasin*</u>: ODEQ 2002 CWA 303(d) list does not indicate that any streams in the Long Tom watershed are water quality limited due to low dissolved oxygen concentrations	City of Creswell's sewage treatment plant Other local sources, agriculture return flows, logging operations N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	<u>*Coast Fork subbasin*</u>: Total dissolved gas may exceed DEQ’s 110% saturation standard in the reservoir during February and March, and as water passes through the outlet gates total dissolved gas increases to exceed DEQ’s standard during July and August (Symbiotics 2005) <u>*Long Tom subbasin*</u>: Total Dissolved Gas (TDG) ODEQ 2002 CWA 303(d) list does not indicate that any streams in the Long Tom watershed are water quality limited due to total dissolved gas	Corps’ reservoir and operations N/A

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites	Habitat Elements	Substrate	<u>*Coast Fork and Long Tom subbasins*</u>: Substrate has probably coarsened downstream of Cottage Grove and Dorena Dams, and the river channels in those areas have likely down-cut. Current sediment budget not creating and maintaining habitat needed by anadromous salmonids In the Long Tom subbasin, Amazon Creek and the lower Long Tom have been channelized, so sediment transport capacity increased and the channels have incised	USACE reservoirs trap sediment from headwaters USACE and private channel modifications Cumulative effects of varied land use Gravel mining Log drives
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	<u>*Coast Fork and Long Tom subbasins:*</u> Large wood abundance has been diminished in most small tributaries and throughout most of the lower portions of these subbasins. Recruitment potential for large wood is low along most surveyed streams	Timber harvesting Stream clean-out Fire suppression Splash-damming of some tributary streams

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	*Coast Fork and Long Tom subbasins*: Pool frequency and quality in the Coast Fork and the Long Tom subbasins have been reduced due to reductions in LWD	Downstream LWD transport blocked by project dams; land uses such as timber harvest, stream clean out, and fire suppression reduce LWD recruitment to stream channels.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	*Coast Fork and Long Tom subbasins*: While no quantitative data are available, the Coast Fork, Row River, and Long Tom River, probably contain fewer off-channel habitats, simplified mainstem habitat, and few new gravel bars or channel surfaces Extensive sections of the mainstem Long Tom River and of its tributary Amazon Creek have been channelized	USACE dam operations reduce the magnitude and frequency of peak flows USACE and private revetments USACE removes large wood from reservoirs Gravel mining in the lower Coast Fork
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth ratio	*Coast Fork and Long Tom subbasins*: While no quantitative data are available, channel form in the lower mainstem rivers has been restricted by revetments, roads and by loss of LWD; reservoir operations have restricted some channel forming processes (USACE 2007a).	Revetments, urbanization, road construction, timber harvest, and agricultural development Corps Project reservoirs and reservoir operations

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	*Coast Fork and Long Tom subbasins*: Streambanks do not support natural floodplain function along the lower mainstem rivers (USACE 2007a).	Revetments, urbanization, agricultural development, road construction, timber harvest USACE Project reservoirs and reservoir operations.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	*Coast Fork and Long Tom subbasins*: Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests	USACE operation of dams reduces the magnitude and frequency of peak flows USACE and private revetments USACE channel straightening on the mainstem Long Tom

Habitat Element	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	*<u>Coast Fork subbasin</u>:* Most riparian vegetation within forested watersheds is less than 60 years old Many tributaries do not provide adequate shading or large wood recruitment Floodplain riparian forests have been diminished Riparian area in lower watershed constrained by I-5 *<u>Long Tom subbasin</u>:* Portions of the upper watershed are forested, but most of it is managed for timber production rather than ecosystem health. More than half (55%) of the riparian corridors in the uplands have had a moderate to high loss of ecological function. Portions of the upper watershed are heavily urbanized Lower portions of the watershed have experienced extensive agricultural, urban, and residential development, causing a high loss of ecological function in 46% of the historical closed bottomland forest.	Timber harvesting Stream clean-out practices Clearing for agriculture or development USACE and private revetments USACE operation of dams alters hydrologic regime Timber harvesting Lowland conversions to agriculture, rural-residential, or urban development USACE and private revetments and levees USACE channel straightening USACE operation of Fern Ridge Dam alters the hydrologic regime

Section 4.10
Mainstem Willamette Baseline

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4.10 MAINSTEM WILLAMETTE

The following information addresses both the entire Willamette River basin, and also specifics related only to the mainstem.

The mainstem Willamette River flows northward from the confluence of the Coast Fork and Middle Fork Willamette rivers for 187 miles before joining with the Columbia River at Portland, Oregon (Figure 4.10-1). At its mouth, the Willamette drains an area of 11,478 square miles and has an annual average runoff of 24 million acre-feet. Upstream of the Santiam confluence (RM 108), the mainstem channel is extensively braided, with many side channels and islands. Downstream of the Santiam confluence, the gradient is lower, complex braided channels are more localized, and lateral changes in the river channel are limited (Hulse 1998). Between the Santiam confluence and Willamette Falls (RM 26), the Salem hills, which cross the Willamette Valley from east to west, and other geologic features constrain the mainstem Willamette so that the channel is much simpler than in the upper subbasin.

The subbasins that drain the east slope of the Coast Range are quite different from those that drain the west slope of the Cascade Range (west slope drainages) (Rosenfeld 1985). The westslope drainages are underlain by older geological formations of a sedimentary origin than are the eastslope watersheds and subbasins, which are of volcanic origin. Accordingly, westslope stream channels tend to be mature, with more downcutting and larger amounts of fine sediment. Westslope streams drain much smaller areas than eastslope streams, and a higher proportion of each westslope stream is on the floor of the Willamette Valley. No westslope streams have headwaters with the snowpack or water-rich volcanic formations associated with large eastslope streams, so their high winter flows decline quickly in spring to very low levels during summer.

Approximately 64% of the land in the Willamette Basin (including all of the subbasins discussed in preceding sections), is privately-owned. The BLM manages 5%, primarily in the Cascade and Coast Range foothills. Within the Willamette valley ecoregion (which extends up to the Coast and Cascade foothills), the vast majority of land is privately-owned with 42% in agriculture, 31% forested, and 11% covered by built features, including urban, rural, and transportation structures (Hulse et al. 2002).

Approximately 1.4 million acres of the Willamette River basin are used for crop production and about 25% of this acreage is irrigated. Rangeland accounts for only a small portion of the lands adjacent to the mainstem, with most located along the mainstem tributaries. Effects of water withdrawals for irrigation are aggravated by agricultural practices that influence erosion, sedimentation and water quality. Extensive sand and gravel mining has occurred in and adjacent to the Willamette mainstem. Aggregate mining within the bed and banks of the river is restricted to bar scalping, except for dredging that is permitted at the Newberg Pool area (USACE 2000).

The largest cities in the upper Willamette Valley include Eugene (population 137,893 in 2000) and Springfield (52,864). Corvallis (population 49,322), Albany (40,852), and Salem (136,924) are the largest mid-valley cities (USCB 2004). Portland (population 529,121 in 2000) is the largest city in the lower Willamette Valley.

Figure 4.10-1 Map of the mainstem Willamette River, its major tributaries, and drainage basin (source: Rounds 2007).

4.10.1 Historical Populations of Anadromous Salmonids in the Mainstem

Multiple populations and ESUs of anadromous salmonids use the mainstem Willamette as a migratory corridor and seasonal rearing area, though the mainstem itself is not known to have ever supported an independent spawning population of these fish. Use of the mainstem above Willamette Falls (Mile 26.6) was restricted historically to the populations of UWR Chinook and UWR Steelhead identified earlier in this document. Below the Falls, these populations shared the mainstem with fish from one or more demographically independent populations of Lower Columbia River (LCR) Chinook, LCR Coho salmon, LCR Chum salmon, and LCR Steelhead. The Clackamas subbasin supported below-Falls populations of fish from each of these lower river ESUs, and smaller spawning aggregates of fish from these ESUs were present in other below-Falls tributaries.

4.10.2 Current Status of Native Anadromous Salmonids in the Mainstem

4.10.2.1 UWR Chinook Salmon

UWR Chinook migrate as adults up the mainstem Willamette during spring, to hold and spawn in eastside tributaries identified in earlier sections of this document, and to rear in and migrate down the mainstem as juveniles after leaving the tributaries. Some juvenile UWR Chinook over-winter at low densities in accessible habitats on the river's floodplain, in intermittent tributaries, and along the lower-most reaches of some larger tributaries in which adults do not spawn (Bayley and Baker 2000); Bayley at al. 2001; Kenaston 2003).

Adult spring Chinook salmon begin appearing in the lower Willamette River in February. The majority of the run ascends Willamette Falls in April and May, with a peak in mid-May (Myers et al. 2002). The early-spring run timing of UWR Chinook salmon relative to other populations in the lower Columbia River is probably an adaptation to low flow conditions at Willamette Falls during summer and fall. Mattson (1963) discussed the existence of a late spring-run Chinook salmon that once ascended the falls in June. These fish were apparently much larger (25 to 30 pounds) and older (presumably 6-year olds) than the earlier part of the run. He speculated that this part of the run intermingled with the earlier-run fish on the spawning grounds and therefore was not distinct. The June run disappeared in the 1920s and 1930s as water quality declined in the lower Willamette River (Myers et al. 2002).

Based on a June 1938 survey described in McIntosh et al. (1995), the upper reaches of the mainstem Willamette, from a point seven miles below the mouth of the McKenzie River upstream to the confluence of the Middle and Coast Forks, contained the best Chinook salmon spawning areas. A short distance below, the river became very sluggish, with mud and silt covering the available spawning rubble. This condition, together with increasing amounts of pollution, lack of good riffle areas, and the high temperatures prevailing in the entire lower section of the Willamette, was reported to render most of the mainstem unsuitable for salmon spawning (McIntosh et al. 1995). More recently (1998), ODFW surveyed the mainstem Willamette River from Island Park (RM 185), near the confluence of the Coast Fork Willamette and Middle Fork Willamette (RM 187) down to Harrisburg (RM 161) on October 1 and October

8, 1998 and found only two redds (Lindsay et al. 1999). These were located approximately four miles below the mouth of the McKenzie River.

Mattson (1962) reported three distinct downstream migrations of juvenile spring Chinook in the Willamette River (Lake Oswego area): a late winter-spring movement of zero-aged fish, a late fall-early winter movement of age-1 fish, and a second spring movement by age-1 fish. More recent work by Schroeder et al. (2005) suggests that these migrations still occur, but at reduced abundance and with temporal shifts in the earliest migrations from Willamette River tributaries that are related to altered thermal regimes below USACE dams. Schroeder et al. (2005) also report that juvenile Chinook exhibit low-density winter use of habitats that are available on the Willamette's floodplain, in intermittent tributaries, and some larger tributaries in which the species does not spawn.

Mattson (1962) found that less than half of each year's brood emigrated in the late winter and early spring as zero-age fish (length 40-90 mm); less than half in the fall as age-1 fish (length 100-130 mm), and less than a third during spring as age-2 smolts (length 100-140 mm). The largest smolts that Mattson (1962) observed in the lower river were 140 mm fork length, a size that by current hatchery standards is small even for juveniles released as 1-year old fish. Portland General Electric (PGE) monitors juvenile salmonid passage at their T.W. Sullivan hydropower plant at Willamette Falls. During 1992 through 1994, the passage of both hatchery- and naturally-produced fish at the Falls peaked in March, with a subsequent and much smaller peak in late November (hatchery fish) and early December (natural fish), similar to the historical timing described by Mattson (1962).

The ODFW conducted beach seines for juvenile Chinook in the upper Willamette River (RM 142 to 177) during summer 2000, 2001, and 2002 (Lindsay et al. 2000; Schroeder et al. 2001, 2005). During July and August, 2001, average lengths of unmarked juveniles increased 5.5 mm over a 6-week period (Schroeder et al. 2001), evidence that juveniles of this species use the mainstem for rearing. The ODFW sampled areas downstream to San Salvador (RM 57) in 2002. Juvenile Chinook were abundant during late June, but numbers were smaller when the area was resampled in late July (Schroeder and Kenaston 2004). The decrease in numbers could have been the result of emigration from the Willamette River or a local shift in fish distribution into areas less accessible by beach seine (hypothetically, due to warmer temperatures).

Juvenile Chinook that ODFW has PIT-tagged in the lower Santiam River (RM 108) and in the main Willamette near Salem (RM 88) during late June have migrated past Willamette Falls (RM 27) by early July (Schroeder and Kenaston 2004). DNA micro-satellite analysis of fin tissues from samples of juvenile Chinook collected from the lower Santiam and from multiple points along the mainstem Willamette downstream in 2002 and 2003 showed these fish to be a mix of native spring Chinook and non-native fall Chinook, with the native fish substantially more abundant (Schroeder et al. 2005). Micro-satellite genetic analysis of fin tissues from 97-100% of juvenile Chinook sampled at Willamette Falls during 2003 and 2004 were native spring-run fish (Schroeder et al. 2005).

Sampling by ODFW along the lower Willamette, below Willamette Falls, during 2000 through 2003 showed juvenile Chinook to be present in each month sampled, though considerably more abundant during the primary migration period in winter and spring (Friesen 2005). The fish were generally larger at the lower end of the river during periods of high abundance than they were at the upper end, suggesting that the fish were growing as they traveled downriver. Yearling Chinook smolts radio-tagged and tracked through the river below the Falls during 2001-2003 had median migration rates of 11.3 km/d and median residence times of 3.4 d (Friesen 2005). Knutsen and Ward (1991) report that Chinook smolts migrated downriver more often through Multnomah Channel than out the mouth of the Willamette River. Smolt migration rates were positively correlated with river flows (Friesen 2005).

Population Viability

The viability and current status of individual populations of UWR Chinook that use the mainstem Willamette was described in specific tributary baseline sections 4.2 Middle Fork Willamette, 4.3 McKenzie, 4.4 Calapooia, 4.5 South Santiam, and 4.6 North Santiam . Although large fish hatchery programs affected confidence in the available abundance estimates for natural-origin UWR Chinook for nearly 50 years, it has long been clear that the decline of these fish has been severe. Total (natural plus hatchery-origin) abundance of adults passing Willamette Falls remained relatively steady after the mid-1950s (ranging from approximately 20,000 to 70,000 fish), but this apparent stability depended on large returns of hatchery-origin fish and already reflected a substantial decline from peak abundances of perhaps more than 275,000 wild adults in the 1920s. Since 2001, as a consequence of improved fish marking and monitoring, estimates of the abundance of natural-origin UWR Chinook have reflected a high degree of confidence in the proportions of the annual runs into individual Willamette River tributaries that were composed of hatchery-origin fish.

Analyses of returns to spawning areas during 2002-2006, a period of relatively high marine survival, suggest an annual run of natural-origin UWR Chinook averaging about 5,000 adults above Willamette Falls (see previous sections), with most of these fish (with a possible exception in the McKenzie subbasin) unlikely to be more than a few generations removed from a fish hatchery. These hatchery-influenced natural returns represent only about 2% of the ESU's historic abundance above the Falls. Below the Falls, returns of UWR Chinook to the Clackamas subbasin, where past hatchery programs replaced a historical run of LCR Chinook (see section 4.8.1), the abundance of natural-origin adults passing North Fork Dam averaged 2,644 during 2002-2004 (Schroeder et al. 2005).

The West Coast Salmon Biological Review Team (WCSBRT, cited as Good et al. 2005) expressed a strong concern that the majority of historical spawning habitat and approximately 30-40% of the habitat once used within the Willamette Basin by these fish is now inaccessible behind dams. The restriction of natural production to just a few areas, most of which now provide altered habitats, increases the ESU's vulnerability to environmental variability and catastrophic events. Losses of local adaptation and genetic diversity through the mixing of hatchery stocks within the ESU represent further threats to viability.

4.10.2.2 UWR Steelhead

The same flow conditions at Willamette Falls that once limited access to all but spring-run Chinook salmon also provided an isolating mechanism for late-run winter steelhead. Fish belonging to populations of UWR Steelhead group of fish enter the Willamette beginning in January and February, but adults do not ascend to their spawning areas until late March or April (Dimick and Merryfield 1945). UWR Steelhead use the mainstem Willamette primarily as a migration corridor on their way to spawning and rearing habitat in the tributaries (ODFW 1990d; Fulton 1970). Spawning takes place from April to the first of June. The ODFW currently uses an artificial passage date at Willamette Falls, February 15th, to discriminate between native versus nonnative (i.e., naturalized Big Creek hatchery stock) winter steelhead (Kostow 1995).1

Emigration of native winter steelhead smolts past Willamette Falls begins in early April and extends through early June (Howell et al. 1985), with peak migration occurring in early to mid-May. Mean lengths of naturally-produced smolts sampled weekly at Willamette Falls (1976 through 1978) ranged from 170 mm to 220 mm. Larger smolts migrated significantly earlier than the smaller smolts (Buchanan et al. 1979).

Sampling by ODFW along the lower Willamette, below Willamette Falls, during 2000 through 2003 showed steelhead smolts to be present during winter and spring (Friesen 2005). The fish were generally larger at the lower end of the river than they were at the upper end, suggesting that the fish were growing as they traveled downriver. Smolts radio-tagged and tracked through the river below the Falls during 2001-2003 had median migration rates of 12.5 km/d and median residence times of 2.5 d (Friesen 2005).

As with Chinook, steelhead smolts migrated downriver more often through Multnomah Channel than out the mouth of the Willamette River (Knutsen and Ward 1991). Smolt migration rates were positively correlated with river flows (Friesen 2005).

Population Viability

The UWR steelhead ESU includes all naturally spawned populations of winter-run steelhead in the Willamette River in Oregon and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive) (NMFS 1999b). It does not include any artificially propagated steelhead stocks that reside within the historical geographic range of the ESU. Hatchery summer steelheads occur in the Willamette Basin, but are an out-of-basin stock not included in the ESU.

The WCSBRT was encouraged by recent significant increases in returns of adult UWR steelhead (exceeding 10,000 total fish) in 2001 and 2002 for the UWR steelhead ESU. However, the recent five-year mean abundance remains low for an entire ESU (5,819 adults), and individual populations remain at low abundance. Long-term trends in abundance are negative for all populations in the ESU, reflecting a decade of consistently low returns during the 1990s. Short-term trends, buoyed by recent strong returns, are positive.

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[1] Stone (1878) reported that steelhead began arriving at the base of Willamette Falls around Christmas, but were most abundant in April. Additionally, the spawning peak was reported to be in May, with spawning complete by June.

About one-third of the ESU's historically accessible spawning habitat is now blocked, but it remains relatively well-distributed spatially within accessible areas within each of its four natal subbasins (Good et al. 2005). The WCSBRT considered the relatively recent cessation of the early-winter-run hatchery program a positive sign for ESU diversity risk, but remained concerned that releases of non-native summer steelhead continue. The WCSBRT found moderate risks for each of the VSP categories.

4.10.2.3 LCR Chinook Salmon

Use of the lower Clackamas, below Willamette Falls, by LCR Chinook salmon is presumed to be relatively similar to that described for UWR Chinook except that upstream migrations of adults might occur during late summer and fall, while juvenile emigration would likely be restricted to sub-yearling fish rearing in and passing through the area during late winter, spring, and early summer.

Population Viability

Many populations within the LCR Chinook salmon ESU have exhibited pronounced increases in abundance and productivity in recent years, possibly due to improved ocean conditions. However, despite recent improvements, long-term trends in productivity are below replacement for the majority of populations in the ESU. Of the historical populations, 8 to 10 have been extirpated or nearly extirpated, including the population that once spawned in the Clackamas River and a few of the smaller Willamette tributaries below Willamette Falls.

The WCSBRT found moderately high risk for all VSP categories. High hatchery production poses genetic and ecological risks to the natural populations and complicates assessments of their performance. The WCSBRT also expressed concern over the introgression of out-of-ESU hatchery stocks.

4.10.2.4 LCR Steelhead

LCR steelhead from the Clackamas subbasin and nearby streams migrate upriver through the lower Willamette River as adults during winter and spring. They emigrate through the lower River as smolts during late winter and spring. Their behavior while in the lower Willamette is as described for UWR Steelhead.

Population Viability

The current status of this evolutionary group of populations was described earlier, in section 3.2.2.3 (Rangewide status, LCR steelhead), with additional detail on the Clackamas population provided in section 4.8.2, Clackamas subbasin baseline. The WCSBRT found moderate risks of extinction associated with the abundance, productivity, spatial structure, and diversity of the group's component populations. Particular concerns included the impact on diversity or productivity of high proportions of hatchery-origin spawners in natural spawning areas and the potential for competitive displacement of native winter-run fish by the offspring of stray spawners from hatchery releases of nonnative hatchery summer steelhead.

4.10.2.5 LCR Coho Salmon

Juvenile coho are present in the lower Willamette below the Falls during winter and spring (Friesen 2005). They appear to grow while in the area. Radio-tagged and tracked coho smolts moved more slowly through the area than did chinook and steelhead smolts, having a median migration rate of 4.6 km/d and a median residence time of 8.7 km/d (Friesen 2005). Smolt migration rates were positively correlated with river flows (Friesen 2005).

Population Viability

The status of this ESU was described earlier in section 3.2.3.2 (Rangewide status, LCR coho salmon), with additional detail on the Clackamas population provided in section 4.8.2 (Clackamas subbasin baseline). There are only two extant populations in the LCR coho salmon ESU with appreciable natural productivity, one of which is the Clackamas population. An extreme loss of natural spawning populations, low abundance of extant populations, diminished diversity, fragmentation, and isolation of the remaining naturally produced fish, confer considerable risks on the ESU (Good et al. 2005). An exceptionally large hatchery program for coho in the lower Columbia continues to represent a threat to the genetic, ecological, and behavioral diversity of the extant natural populations. However, the hatchery stocks present in the lower Columbia collectively represent a significant portion of the LCR Coho ESU's remaining genetic resources. The 21 hatchery stocks considered to be part of the ESU, if appropriately managed, may prove essential to the restoration of more widespread naturally spawning populations.

4.10.2.6 Limiting Factors & Threats to Recovery

Multiple conditions in the mainstem above Willamette Falls, or in the river corridor downstream of the Falls, unfavorably affect the status of ESA-listed populations of anadromous salmonids. These conditions have been summarized by ODFW (2007b) and are given in Table 4.10-1. Key limiting factors and threats to UWR Chinook and UWR steelhead from above-Falls populations, while in the mainstem above the Falls, include habitat impairments associated with flood control and land use, as well as Project-caused reductions in spring flows that elevate river temperatures and disease risks that the parasite *Ceratomyxa shasta* poses for steelhead smolts. Below Willamette Falls, anadromous salmonids using the lower Willamette and Columbia rivers are unfavorably influenced by multiple factors associated with USACE dams on both systems, by habitat degradation caused by the cumulative effects of varied land uses, competition with juvenile hatchery fish produced by programs funded by the USACE and others, predation, and toxic chemicals from agricultural, urban, and industrial practices.

Table 4.10-1 Key and secondary limiting factors and threats along the mainstem Willamette River to the recovery of UWR Chinook, UWR Steelhead, and fish from multiple ESA-listed populations of anadromous salmonids that might be found in the lower Willamette, below Willamette Falls (ODFW 2007b).

		Mainstem Willamette Above Falls (above-Falls populations)						Areas below Willamette Falls (all populations)		
		Middle Fork, McKenzie populations		Calapooia, N. Santiam, S. Santiam populations		Molalla populations				
Threats	Species	Parr	Smolt	Parr	Smolt	Parr	Smolt	Fingerling/ Sub-yearling	Yearling	Adult
Harvest	Chinook									
	Steelhead									
Hatchery	Chinook							4a		
	Steelhead								4a	
Hydropower/ Flood Control	Chinook	10d		10d				5a,5b,7h,10f 9j		
	Steelhead			10d	10c				5a,5b,7h,10f 9j	
Landuse	Chinook	8a		8a				5a 6e,8a,9a,9h,9i		
	Steelhead			8a					5a 6e,8a,9a,9h,9i	
Introduced Species	Chinook									
	Steelhead									

Black cells = key concerns; Gray cells = secondary concerns; Cross-hatched cells = no populations.

Key threats and limiting factors

- 5a Reduced macrodetrital inputs from near elimination of overbank events and the separation of the river from its floodplain.
- 5b Increased microdetrital inputs due to reservoirs.
- 7h Impaired fine sediment recruitment due to dam blockage.
- 8a Impaired physical habitat from past and/or present land use practices.
- 10c Reduced flows during spring reservoir filling result in increased water temperatures that lead to increased disease.
- 10f Altered flows due to hydropower system that result in changes to estuarine habitat and plume conditions, impaired access to off-channel habitat, and impaired sediment transport.

Secondary threats and limiting factors

- 4a Competition with hatchery fish of all species.
- 6e Predation by birds as a result of favorable habitat conditions for birds created by past and/or present land use activities.
- 8a Impaired physical habitat from past and/or present land use practices.
- 9a Elevated water temperatures from past and/or present land use practices resulting in decreased survival and/or growth.
- 9h Toxicity due to agricultural practices.
- 9i Toxicity due to urban and industrial practices.
- 9j Elevated water temperatures due to reservoir heating.
- 10d Reduced peak flows leading to decreased channel complexity and diversity of fish habitat by reducing channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. Lower peak flows also reduces scour and formation of pools.

4.10.3 Environmental Conditions

4.10.3.1 Habitat Access

Safe and effective passage of adult anadromous salmonids up the Willamette River and of juvenile anadromous salmonids down the river are critical to the ability of these fish to complete their migratory life cycles. The general relationships between safe fish passage, access to historical habitat, and the habitat requirements of UWR Chinook salmon and steelhead are described in detail in Appendix E. Table 4.10-3 summarizes the status of safe passage and access to habitat in the mainstem Willamette River under the environmental baseline, which is described in more detail below.

4.10.3.1.1 Willamette Falls as an Impediment or Barrier to Migration

Willamette Falls at Mile 26.6 is a bedrock sill that under natural conditions could be passed by upstream migrant salmon and steelhead only during winter and spring high flows. Opportunities for upstream fish passage at the Falls during less than high-flow conditions were then expanded by a series of early changes that included the construction of navigation locks in 1873 and of a crude rock fishway in the mid-1880s to early 1890s (ODFW 1990d). The effectiveness of the crude fishway was compromised, however, when subsequent hydropower development diverted flows away from its entrance to an area called the cul-de-sac, creating an area of false attraction for upstream migrants. A modern fish ladder completed in 1971 corrected the situation by providing entrances at several points around the falls area. Multiple additional improvements are now being made to correct upstream passage problems associated with specific features of the Willamette Falls Hydroelectric Project: the Sullivan Powerhouse, Blue Heron Powerhouse, and a low concrete dam at the top of the Falls. As part of Portland General Electric’s (PGE) new FERC license for this hydroelectric project (PGE 2004), continuous summer flow is provided to pools where adult fish can become stranded at the base of the Falls, Blue Heron Powerhouse was decommissioned to eliminate false-attraction of adults to its tailrace, and the existing ladder is being upgraded and better maintained.

Downstream passage conditions for salmonids migrating past Willamette Falls may rarely have been ideal under natural conditions, but were made less favorable when the site was developed for power production, beginning in 1891. At one point in the site’s developmental history, as many as 52 turbines were operated by several entities, each with the potential to cause high rates of injury and mortality to juvenile outmigrants. Massey (1967) estimated that during peak emigration (March through July), one-third of the downstream migrants passed through turbines at the Sullivan Plant. The Oregon State Game Commission measured mortality rates ranging from 7.7% to 100% for those juvenile Chinook salmon that passed through turbines at Willamette Falls in 1960 and 1961 (Thompson et al. 1966). Since then, all but 13 of the turbines have been removed, and PGE has installed an Eicher screen on the turbine that was found to pass the greatest percentage of fish. As mitigation for some of the project’s effects on anadromous fish, the FERC license includes the following improvements to downstream passage conditions:

- structural improvements to the Sullivan Powerhouse bypass system, including 2006 construction of a siphon bypass spillway at the downstream end of the forebay to pass juvenile fish around the turbines;
- permanent closure of the unscreened Blue Heron Powerhouse in 2003;

- completion in 2007 of a Flow Control Structure at a low concrete dam atop the Falls, to direct over-falls flow toward safe fish landing areas; and
- additional downstream passage improvements if needed to meet performance standards required by the new FERC license (PGE 2004). These standards include 98% smolt survival rates past the Sullivan Powerhouse, and 96% survival for emigrant fry.

4.10.3.1.2 Other Migration Impediments

Willamette Falls poses the only natural and artificial physical impediment to fish migration up or down the mainstem Willamette River. However, passage is no longer an impediment at the Falls due to passage improvements required in the FERC license and implemented by the licensee. Water quality conditions may at times affect the suitability of the river as a migration corridor. Such conditions are discussed in section 4.10.3.3.

4.10.3.2 Water Quantity/Hydrograph

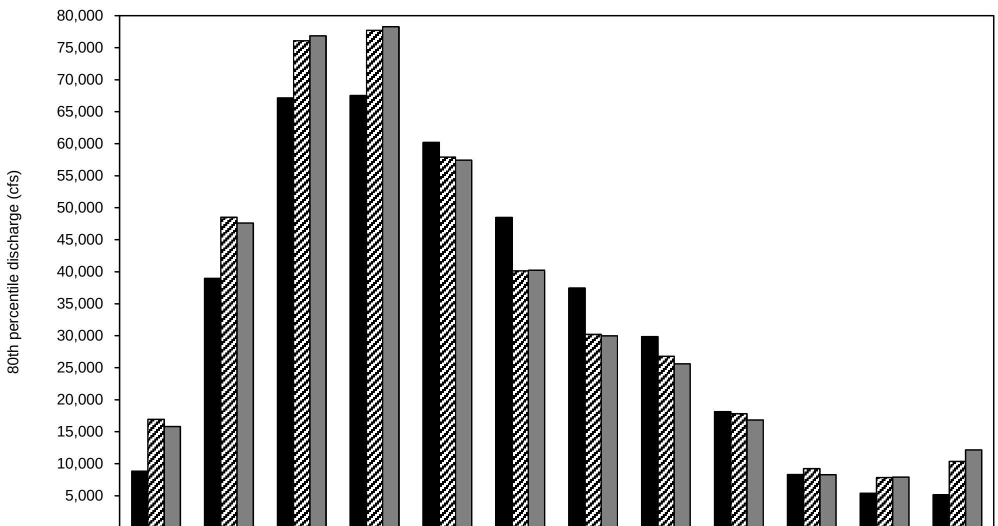
The Willamette Project has changed the shape of the annual hydrograph of the Willamette River (Figures 4.10-2 A, B & C). A fraction of late-winter and spring runoff is now stored in reservoirs, reducing mainstem flows at those times of year, in order to augment flows in the summer and early fall. Late season flows remain low, but are higher now than they were prior to USACE dam construction. For example, the average annual 7-day low flow since completion of the Project has been almost twice that recorded in pre-project years.

The Willamette Project as a whole is operated to maintain year-round flows of at least 4,500-5,000 cfs in the Willamette River at its confluence with the Santiam River near Albany, Oregon and in excess of 6,000-7,000 cfs at Salem, Oregon. Maintaining such flows requires augmentation through reservoir drafting during August, September, and October in most years, and frequently requires augmentation in June and July as well. Since 2001, the Project has been managed with a greater emphasis on providing flows beneficial to ESA-listed salmonids, including efforts to hold minimum flows higher during spring through early fall to the degree feasible (see Figures 4.10-2 A, B & C and Table 2-8 in Chapter 2, Proposed Action). These recent efforts have enhanced minimum flows during the seasons identified relative to those that might have occurred without changes in Project operations.

The OWRD has issued permits for surface water withdrawals totaling 24,746 cfs for all uses throughout the Willamette basin. This is a maximum allowable diversion right and actual diversions are much lower at any particular time. Much of the diverted water is not consumed and returns to the river downstream from the point of diversion. Agricultural irrigation dates back to 1890 and is the largest water use in the basin, about 401,549 acre-feet per year (accounting for about 33% of total water use). Most of the early development took place near the cities of Portland, Salem, and Eugene, proceeding slowly through the first four decades of this century. About 1,000 acres were irrigated by 1911; 3,000 acres by 1920; 5,000 acres by 1930; and 27,000 acres by 1940. Since 1940, irrigation development has increased ten-fold. Total irrigated acreage in 1994 was between 240,000 and 290,000 acres, and water demands have increased accordingly (ten-fold) (OWRD 1999).

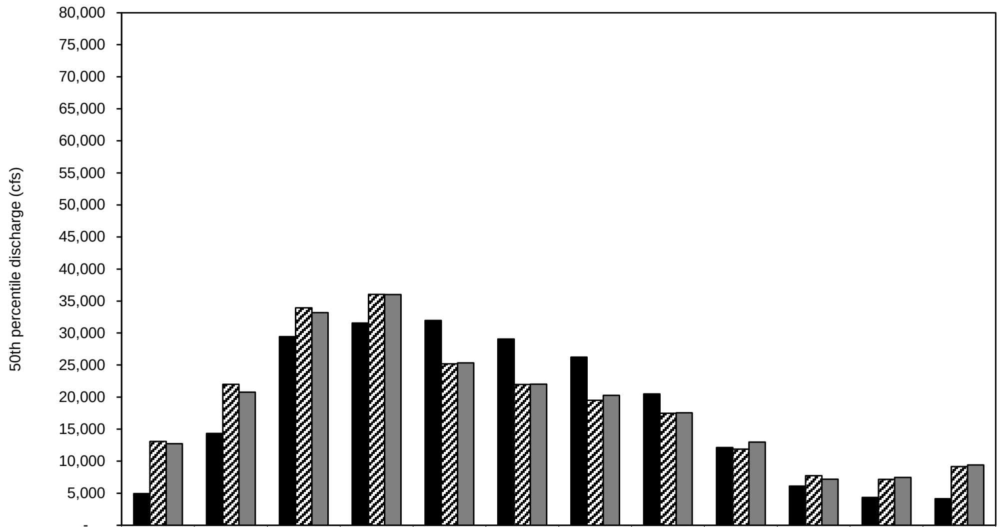
Before 1930, most of the water for irrigation came from surface sources but since then, there has been a growing reliance on groundwater. In 1990, the USGS estimated that 63% of water for irrigation in the basin came from surface sources and 37% from groundwater sources (OWRD 1999). Irrigated lands are distributed fairly evenly across the basin. Approximately 13% of the land that is irrigated with surface water sources is located in the region above Harrisburg, 24% in the upper mid-valley region above Albany, 32% in the lower mid-valley region above Salem, and 31% in the region below Salem (Table 4.10-2 A, B & C).

Figures 4.10-2 A, B & C. Simulated discharge (cfs) of the Willamette River at Salem, Oregon under unregulated conditions (Unreg), with project operating criteria prior to 2000 (Pre-2000), and with project operating criteria after 2000 (Post-2000), depicting the 80th, 50th (median), and 20th percentile for each scenario.



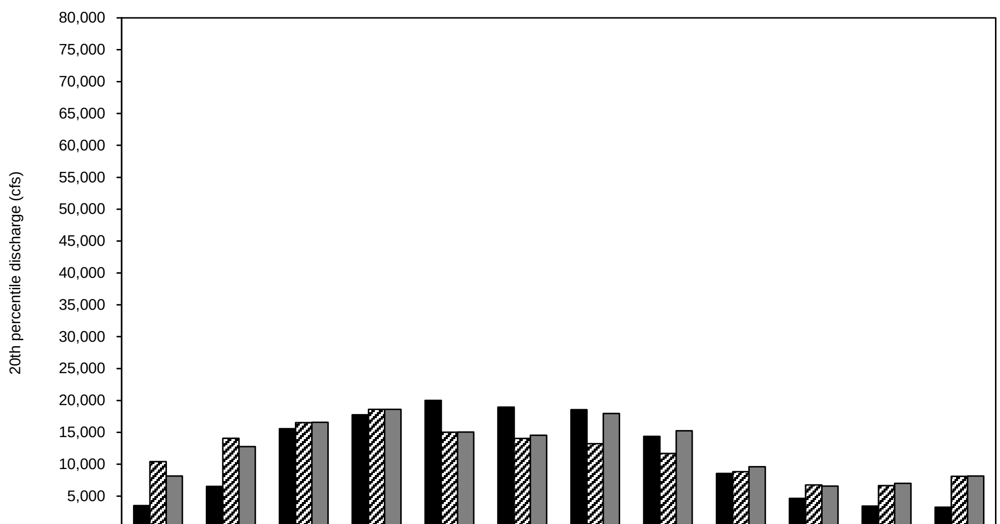
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	8,848	38,964	67,142	67,522	60,221	48,473	37,452	29,865	18,141	8,326	5,398	5,157
Pre-2000	16,931	48,492	76,077	77,707	57,909	40,139	30,191	26,778	17,807	9,245	7,820	10,366
Post-2000	15,814	47,619	76,845	78,278	57,437	40,246	29,977	25,602	16,846	8,288	7,929	12,149

Figure 4.10-2 A



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	4,924	14,344	29,429	31,554	31,964	29,061	26,242	20,509	12,124	6,112	4,320	4,134
Pre-2000	13,086	22,008	33,942	36,023	25,174	21,986	19,516	17,455	11,888	7,758	7,158	9,151
Post-2000	12,738	20,775	33,179	36,005	25,349	22,037	20,284	17,560	13,001	7,200	7,471	9,410

Figure 4.10-2 B



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Unreg	3,540	6,553	15,569	17,755	20,030	18,969	18,550	14,372	8,552	4,644	3,442	3,271
Pre-2000	10,405	14,097	16,521	18,619	15,033	14,057	13,222	11,695	8,824	6,748	6,656	8,114
Post-2000	8,156	12,763	16,580	18,623	15,048	14,536	17,954	15,265	9,600	6,581	6,989	8,134

Figure 4.10-2 C

Table 4.10-2 Distribution of irrigated land, type of irrigation water, and total acres of irrigated lands in four regions of the Willamette River basin, Oregon, in 1990 (OWRD 1999).

Region	Surface Water	Ground Water	Total Irrigated Acres
Upper Region (above Harrisburg control point)	68.1%	31.9%	34000
Mid-Valley Region (above Albany control point)	73.7%	26.3%	60560
Mid-Valley Region (above Salem control point)	54.1%	45.9%	108430
Lower Region (below Salem control point)	66.9%	33.1%	85700
Totals	63.7%	36.3%	288690

Water withdrawn anywhere from the Willamette Basin, whether in a tributary or on the mainstem affects flow in the mainstem Willamette River. In total, the USBR has issued 205 water service contracts for 59,231 acre-feet of water stored in Willamette Project reservoirs for irrigation (USACE 2007a). The largest contract provides for up to 9,625 acre-feet for the irrigation of 3,500 acres. Another five contracts individually serve more than 400 acres and provide for more than 1,000 acre-feet annually. The other 199 contracts currently in effect serve smaller numbers of acres and are almost all with individual water users. The amount of water actually used is less than the amount contracted (USACE 2007a).

As a subset of the entire USBR water contract program, on the mainstem Willamette itself there are a total of 49 long-term Reclamation water service contracts in effect on the mainstem for stored water from the Willamette Project. Cumulatively, these 49 contracts can withdraw a maximum of 10,971 acre-feet of stored water for irrigation.

The Willamette basin is home to over 2 million people, almost 70% of Oregon's population. The Willamette River and its tributaries provide for substantial fraction of this population's domestic and industrial water needs and the OWRD has issued water permits that total 2,737 cfs for municipal use from surface waters in the basin. The OWRD has also issued industrial uses water rights for diversions totaling 1,248 cfs and 13,691 cfs for hydropower.

Refilling the Willamette Project reservoirs during the late winter and spring (February through May) has reduced mainstem flows during the primary period of juvenile emigration from the system, adversely affecting migrating juvenile anadromous salmonids.2 ODFW (Mamoyac et al. 2000) has investigated the smolt-to-adult returns of Willamette basin winter steelhead and has determined that during years when average May flows fell below 15,000 cfs at Salem, Oregon, the number of recruits per spawner declined. These recruit per spawner data also corresponded to in-river temperature conditions above 14-15°C. Willamette River water temperatures during May tend to increase as flows decline. ODFW (Mamoyac et al. 2000) has identified *Ceratomyxa shasta* as the most likely causal agent for poor steelhead smolt-to-adult survival at low flows and

[2]Most steelhead smolts migrate out of the Willamette system during March through June, with a peak in May. Spring Chinook juvenile migration timing in the basin tends to be more variable, with about half the annual outmigration taking place between February and June, peaking in May and half of the annual migration taking place between September and December, with a peak in late October.

warm temperatures. The virulence of *C. shasta* to steelhead is known to increase at temperatures above 15°C. Flows below 15,000 cfs also tend to increase the disease's virulence by contributing to warmer water temperatures. Also, as flows decrease, the average velocity decreases, particularly in large pools like the Newberg pool (a 45-mile stretch of deep, slow water between Willamette Falls and Wheatland Ferry north of Salem), thereby increasing smolt travel time and the duration of exposure to all causes of mortality in the river, including pathogens, toxins, and piscivorous fishes.

ODFW (Mamoyac et al. 2000) also investigated the relationship between flow and survival, although the data do suggest a positive correlation between survival and flow and a negative correlation between survival and temperature. Both Chinook and steelhead smolts have been found to migrate more slowly as flows decline in the lower Willamette below Willamette Falls (Freisen 2005), suggesting that durations of exposure to unfavorable conditions there may rise at the same time that the severity of such conditions increases.

Adult migrants can also be affected by reduced flows. At very low Willamette River flows (10,000 cfs and below) significant low-flow related passage delays have been observed at PGE's Willamette Falls (T.W. Sullivan) hydropower project at Oregon City (Mamoyac et al. 2000), the most significant passage obstruction on the river. Passage time also increases as flows exceed 25,000 cfs at Willamette Falls, a condition that has been reduced by Willamette Project refill operations. At lower river flows and warmer temperatures adult spring Chinook salmon also tend to have a greater rate of pre-spawning mortality (Schreck et. al 1994). By reducing spring flows in the mainstem Willamette River the Willamette Project has complex and variable effects on adult salmonids. When natural Willamette River flows would otherwise exceed 25,000 cfs, spring storage operations at Willamette Project reservoirs may benefit spring Chinook salmon by reducing passage delays at Willamette Falls. At natural flow levels below 10,000 cfs, spring storage activity at Willamette Project reservoirs probably exacerbates passage delays at the Willamette Falls project and contributes to pre-spawning mortality in the river. In general, the period of poorest adult spring Chinook survival tends to occur after June 1 (Schreck et al. 1994), when the projects are usually passing inflow or augmenting flow.

Studies have shown that the mainstem Willamette River exhibits a fairly narrow period of optimal conditions for adult spring Chinook migration and survival to spawning areas (Schreck et al. 1994). Fish that pass Willamette Falls early in the season (April) tend to move slowly upstream, presumably due to cold water conditions, and may have difficulty maintaining their motivation to migrate. Some succumb. Mid-season migrants (May) move quickly upstream and reach holding areas in the spawning tributaries. Mid-season migrants survive well to the spawning tributaries. Late migrants (June) tend to move quickly to points near Salem and Albany where a substantial fraction remain and die. This general pattern varies with prevailing hydrologic and climatic conditions. In warmer, drier years the early migrants may behave like mid-season migrants and mid-season migrants may behave more like late season migrants. In wetter, cooler conditions, the behavior shifts toward that of early season migrants. These data suggest that reservoir filling during low water years may increase adult passage delays and contribute to pre-spawning mortality in the Willamette River. This effect appears to be small to negligible at river flows in excess of 10,000 cfs at Willamette Falls.

Aggregate water use in the basin has reduced streamflow, particularly during the summer irrigation season, potentially reducing the area suitable for rearing juvenile salmon and increasing adult passage delays, particularly during low water years.

Hydropower developments throughout the basin contribute to passage delays and passage mortality, and an array of water diversions diminishes flows and entrains juvenile fish. (Although the OWRD now requires that surface water diversions throughout the basin be screened to minimize fish entrainment, not all diversions are currently screened.)

The increase in late summer and early fall flows provided by USACE flow augmentation and reservoir drawdown operations probably benefits anadromous salmonids by increasing habitat area, reducing passage delays, and by improving water quality.

Summary

Human-caused alterations of the hydrologic regimes of the lower mainstem Willamette River and its principal tributaries have generally diminished flow-related habitat quantity and quality, and have reduced the numbers, productivity, and life history diversity (adult run timing and juvenile outmigrant strategies) of spring Chinook salmon and winter steelhead, and limited the production potential of accessible habitat in much of the basin.

Below Willamette Falls, the effect of project-related flow reductions during spring may be to incrementally increase exposures of juvenile salmonids to less than desirable conditions in that area by slowing their emigration rates.

4.10.3.2.1 Peak Flow Reduction

The 13-reservoir Willamette Project controls runoff from 27% of the Willamette Basin. Flood flows greater than 200,000 cfs were common at Albany, Oregon, prior to construction of the reservoir system (the recurrence interval was approximately 3.5 years; USACE 2000). The largest flow ever recorded at the Albany gauge (USGS Station No. 14174000) was 266,000 cfs on January 14, 1881, and larger, unrecorded floods were reported in 1861 and 1890. Between 1895 and 1941, the average annual maximum flow rate at Albany was over 106,000 cfs; floods were "flashy," building rapidly to a peak (USACE 1980). Since the USACE completed the flood control projects, the average annual maximum flow has been approximately 69,000 cfs. Operations have decreased the magnitude and frequency of extreme high flow events, and have increased the duration of moderate flows (22,000 to 45,000 cfs) and low flows (5,000 to 10,000 cfs).

Reductions in peak flows caused by USACE flood control operations have contributed to the loss of habitat complexity in the mainstem Willamette River by substantially reducing the magnitude of the channel-forming dominant discharge (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control tends to reduce channel complexity (e.g., reduces the frequency of side channels, and woody debris recruitment) and reduces the movement and recruitment of channel substrates. Side channels, backwaters, and instream woody debris accumulations have been shown to be important habitat features for rearing juvenile salmonids. Operation of USACE's Willamette Project reservoirs is only partly responsible for the reduction in channel complexity noted in the mainstem Willamette River. Bank stabilization and channelization measures and land leveling and development in the basin have directly reduced channel complexity and associated juvenile salmon rearing habitat. These human-caused direct physical changes in the river's complexity have been massive. For example, Benner and Sedell (1997) estimated that the total length of channel between Eugene and Albany has been reduced by 45% to 50% since 1850.

4.10.3.2.2 Altered Flow Effects on Spawning Success

The mainstem Willamette is generally not used for spawning by UWR Chinook or UWR Steelhead, although occasional use by spawning UWR Chinook has been reported for areas near the confluence of the McKenzie or farther upriver. Effects of USASCE-induced changes in mainstem flows during fall and winter on egg survival when Chinook redds are constructed in these areas are unknown, but any decreases in survival are likely to be small or negligible due to the attenuation of such changes with increasing distance from dams. Reductions in mainstem peak flows may increase egg survival in these areas by reducing risks of redd scour.

4.10.3.2.3 Flow Fluctuations, Entrapment & Stranding

Due to the distance from the projects, contributions from uncontrolled tributaries, and the attenuating effects of channel storage, rapid discharge fluctuations at the various Willamette Project dams are unlikely to result in rapid discharge fluctuations in the mainstem Willamette River. Thus the potential for project operations to cause stranding of juvenile salmonids in the mainstem Willamette River is very small.

4.10.3.3 Water Quality

Water quality conditions in the mainstem Willamette have improved noticeably from the severely poor conditions that prevailed along much of the river in the early to mid-1900s, when un- or little treated municipal and industrial wastes were discharged directly into the river. Recent trends in an integrated water quality index (the OWQI[3]) have generally been positive, though water quality during some months remains less than good along the mainstem as far upstream as Albany (at Mile 119.3) and poor from Newberg (Mile 48.6) down to the mouth (Cude 1996a, 1996b, 1996c). Despite the problems that remain, however, water quality conditions in the river place less severe constraints on sensitive fishes like UWR Chinook and UWR Steelhead than they did in the 1930s or 40s, a time when the Willamette Basin was producing well over an order of magnitude more wild UWR Chinook than it does at present. For example, Hughes and Gammon (1987) compared the results of historical and more recent longitudinal surveys of the river and concluded that there had been marked improvements in fish community quality since 1945.

The general relationships between water quality and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E. Table 4.10-3 summarizes water quality conditions in the mainstem Willamette River under the environmental baseline, and which are described in more detail below.

[3] The Oregon Water Quality Index (OWQI) incorporates quantitative information on the following water quality constituents: temperature, nutrients (phosphorous and nitrogen), biochemical oxygen demand, dissolved oxygen, total solids, *E. coli* bacteria, and pH.

4.10.3.3.1. Water Temperature

The mainstem Willamette River exceeds Oregon temperature criteria intended to protect its value as salmonid habitat (ODEQ 2006a). From the confluence of the Middle and Coast forks (at Mile 187) downriver to Newberg (Mile 50.6), temperatures greater than criteria for salmonid rearing and migration habitat (18^{o}C) are common from as early as mid-June to as late as mid-September, and those exceeding the standard for salmon spawning (13^{o}C) have been recorded in the fall (ODEQ 2006a). From Newberg to the mouth, the Willamette exceeds a temperature standard established to maintain suitable migration conditions for salmon and steelhead (20^{o}C) from as early as mid June to as late as mid-September (ODEQ 2006a). The frequency and magnitude of these temperature exceedences are partly a consequence of natural processes and conditions, but they also reflect man-caused changes within the river basin (ODEQ 2006a). Temperatures in the mainstem Willamette have been influenced by a variety of land and water uses, changes in channel morphology related to past USACE effort to simplify and stabilize the river itself, riparian alterations associated with development and flood control, and altered temperature and discharge patterns immediately below USACE dams on the river's tributaries (ODEQ 2006a).

Willamette Project flood-control reservoirs have an influence on water temperatures in the mainstem Willamette related to release temperatures, discharge volumes, and distance downriver (ODEQ 2006a). The reservoirs store late winter and spring runoff, and then release it to augment streamflows during the dry months of summer and early fall. Consequent reductions in spring flows in the Willamette's tributaries can lead to early warming of the mainstem and may lead to increased losses of emigrant steelhead smolts to the native parasite C. shasta (which becomes more virulent above 15^{o}C) (ODFW 2007b). Greater than natural flows of cold water released from the deep, thermally stratified reservoirs during summer months may in some cases be too cold for optimal salmon growth immediately below the dams (ODEQ 2006a), but also reduces temperatures lower in the tributaries and the mainstem Willamette (USACE 1982), to the potential benefit of salmonids in those areas.

Thermal stratification in the reservoirs then breaks down in late summer or early fall, causing the temperature of released water to be warmer than natural as reservoirs are drawn down to increase flood storage capacity in the fall. The increased temperatures during fall can be too warm to fully support salmonid spawning and egg incubation (ODEQ 2006a; ODFW 2007b). The degree to which mainstem Willamette temperatures are elevated at this time of year is greatest in the upper river (ODEQ 2006a), where evidence of salmon spawning has been observed. Warmer than natural river temperatures during fall can result in elevated egg mortality, accelerated development of incubating Chinook salmon eggs, and premature fry emergence from the spawning gravels. Chinook fry that emerge too early tend to experience poorer river conditions, and thus are likely to have lower survival rates than they would have if egg development had followed a more natural pattern.

The USACE has long recognized the potential for Willamette Project reservoirs to have adverse thermal effects on salmonids using river reaches below its dams at certain times of year. In 2004, Cougar Dam on the South Fork McKenzie was fitted with a multi-level intake that allows for selective withdrawal of water from various reservoir depths and better matching of outflow to inflow temperatures. USACE operations will continue to have seasonally unfavorable thermal effects on ESA-listed salmon downriver from other flood-control dams until additional selective withdrawal structures or their equivalent are installed.

Summary

Temperatures in the mainstem Willamette River have been altered by a variety of man-caused changes in the drainage basin, including the operation of Willamette Project reservoirs and USACE modifications to the river channel. The mainstem is kept cooler by USACE flow augmentation during summer but is warmer than normal in the late summer and fall. The direct thermal effects of reservoir operations may be beneficial to salmonids in the Willamette during summer, but less than favorable for emigrating steelhead smolts during spring (when temperatures in years of low runoff may be warmer due to reduced spring flows) and are clearly unfavorable for any UWR Chinook that may spawn in river segments near the McKenzie River confluence or farther upriver. Degraded riparian conditions that are partly a consequence of flood control efforts have tended to warm the mainstem during spring and summer, and channel simplification by the USACE has likely reduced thermal heterogeneity and the availability of cool thermal refugia important to salmonids when mainstem temperatures are warm.

4.10.3.3.2. Dissolved Oxygen

Depressed concentrations of dissolved oxygen were common in the lower mainstem Willamette River during the first half of the 20th century as a consequence of serious water quality problems caused by little-regulated urban and industrial development. Human and industrial wastes were being discharged into waterways (Fish and Wagner 1950), creating problems that were pronounced in the mainstem from Newberg to the mouth (USACE 1982). Below Willamette Falls, high levels of bacterial decomposition and respiration caused dissolved oxygen concentrations to drop below 5 mg/l during August (Fish and Wagner 1950), creating an "oxygen block".[4] This "oxygen block" precluded fish migrations, including those of species now listed under the ESA. Passage generally occurred when dissolved oxygen concentrations were greater than about 3.5 to 5 mg/l (Alabaster 1988). The river's water pollution and dissolved oxygen problems were eventually minimized by treating domestic and oxygen-consuming industrial wastes (reducing oxygen demand in the river by about 30%), and by augmenting flows and reducing peak temperatures through management of Willamette Project reservoirs (USACE 1982).

Despite improvements, available data suggest that dissolved oxygen concentrations in portions of the mainstem Willamette are at times falling below ODEQ numerical criteria intended to protect beneficial uses that include salmonid rearing and spawning. Results of a dissolved oxygen study described by Pogue and Anderson (1995) indicate that dissolved oxygen fell below 90% saturation (an ODEQ criterion established to protect salmonid habitat) in the mainstem Willamette River from RM 151 to 141.6 (just above Peoria, Oregon) during the summer rearing period. The lowered dissolved oxygen concentrations were probably the result of respiration by periphyton (attached algae). The ODEQ's 2004/2006 Integrated Report database indicates that dissolved oxygen levels in the mainstem Willamette River between RM 54.8 (mouth of the Yamhill River) and RM 186.5 (the confluence of the Coast and Middle forks) have also fallen below numerical criteria intended to protect spawning salmonids or their incubating eggs from

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[4] "The major pollution of the Willamette and its tributaries [in 1951] is caused by the discharge of raw sewage from 473,650 people, treated sewage from 45,500, wastes from 6 pulp mills and a variety of other industrial plants. The total organic wastes discharged from all municipal sources of pollution have a total population equivalent of 953,800. Fifty-six industries are known to be discharging organic wastes directly to the water courses with a population equivalent of 2,963,750" (Federal Security Agency 1951).

October 15 through May 15. These lower dissolved oxygen levels, while below the criteria, are not much lower.

Given the locations and seasons of the documented exceedances of ODEQ criteria, dissolved oxygen concentrations in the mainstem might at times be having small effects on juvenile UWR Chinook rearing in the mainstem during summer and on the survival to fry emergence of any UWR Chinook eggs deposited in the upper mainstem.

Flow augmentation from Project reservoirs and basin-wide secondary sewage treatment increased dissolved oxygen levels in the mainstem Willamette River and have contributed to positive changes in the native fish communities found in the mainstem Willamette. Compared to observations made in 1945, the river currently supports increased numbers of fish species that are relatively sensitive to low dissolved oxygen levels (Hughes and Gammon 1987).

Summary

Pollution-related dissolved oxygen problems in the mainstem Willamette River have been substantially reduced from those in the early 20th century, due in part to the construction and operation of Willamette Project reservoirs and in part to treating waste water. Fish communities in the river have responded to this improvement, though dissolved oxygen levels in the river remain less than optimal at some locations and in some seasons.

4.10.3.3.3 Total Dissolved Gas

There is no information indicating that total dissolved gas concentrations in the mainstem Willamette River have exceeded 110% of saturation.

4.10.3.3.4 Nutrients

The ODEQ's 2004/2006 Integrated Report database does not indicate that the mainstem Willamette River is water quality limited due to nutrient loadings.

4.10.3.3.5 Turbidity

The ODEQ's 2004/2006 Integrated Report database does not indicate that the mainstem Willamette River is water quality limited due to turbidity.

4.10.3.3.6 Toxics

Numerous organic pesticides are present in Willamette Basin streams, and some of these pesticides are present at concentrations that approach criteria for the protection of human or ecological health (Anderson et al. 1996). The Willamette Pesticides Project (Phase III), a cooperative effort between the USGS and the ODEQ, studied a representative set of 16 small streams that each drained approximately 10 square miles of primarily agricultural land (Anderson et al. 1996). Four sites draining primarily urban land were also included, to provide a comparison between agricultural and urban land uses. Water-quality samples were taken five times between April and November, 1996, twice coinciding with spring storms, once during the summer low flow period, and twice during fall storms. Basinwide, a total of 36 pesticides (29 herbicides and 7 insecticides) were detected that could find their way into the Willamette River. The five most frequently detected compounds were the herbicides atrazine (99% of samples), desethylatrazine (93%), simazine (85%), metolachlor (85%), and diuron (73%). Although the transport of contaminants to streams is related to discharge and the amount of runoff, correlations between discharge and pesticide concentration were poor (Anderson et al. 1996). In general, pesticide concentrations were greater in smaller than in larger tributary streams (Anderson et al. 1996).

Bacterial contamination is an intermittent problem along the mainstem Willamette during periods of elevated runoff from fall through spring (ODEQ 2006a). However, concerns related to this contamination focus primarily on the protection of human health and any effects of the elevated bacteria levels on salmonids are unclear. Combined sewer overflows (CSOs) during fall through spring remain a particular human health concern in and below the Portland metropolitan area (ODEQ 2006a). Portland's CSOs are not known to have a major effect on UWR Chinook or UWR Steelhead, but are being addressed by $1.4 billion changes in infrastructure that will better isolate the remaining 35% of the city's sewage treatment system influenced by stormwater runoff (Portland 2007).

The ODEQ's 2004/2006 Integrated database indicates the following exceedences of water quality criteria for the protection of anadromous fish:

- DDT - 2 out of 7 water column samples at RM 12.7 exceeded the criterion of 0.000024 pg/L
- Polynuclear aromatic hydrocarbons (PAH) - at RM 6 the 35-day average concentration of 52,900 pg/L exceeded the criterion of 2,800 pg/L

Summary
Available data suggest that small streams draining agricultural lands in the Willamette Basin, such as those valley floor tributaries that are sometimes used as over-wintering areas by juvenile UWR Chinook, may contain one or more organic pesticides at levels approaching those of environmental concern. Below Willamette Falls, concentrations of DDT and of PAH measured in the mainstem Willamette have exceeded criteria established to protect anadromous fish.

4.10.3.4 Physical Habitat Characteristics

The general relationships between natural processes that create and maintain complex stream channels, and the habitat requirements of UWR Chinook salmon and steelhead, are described in Appendix E. Many of these processes within the Willamette Basin have been substantially altered by human actions, including the construction and operation of USACE dams, historical alterations to the Willamette River channel, and varied landuses both in upland areas and on the floor of the Willamette Valley. Table 4.10-3 summarizes the status of key habitat components along the Willamette mainstem under the environmental baseline, which is described in more detail below.

Substrate
Substrate conditions at various points along the mainstem Willamette reflect a combination of natural landscape-level processes, adjacent topographic features, and the cumulative effects of man-caused changes in the surrounding watershed. Fine-textured sediments predominate below Newberg and particularly below Willamette Falls, due to low channel gradients. Gravel is mined extensively from the river for navigational, commercial, and private purposes. The Division of State Lands permitted extraction of close to 60 million cubic yards from the mainstem between 1967 and 1994 (OWRRI 1995). Many commercial operations extract gravel from the river's

floodplain, and private and commercial operations also remove gravel from bars exposed by low summer flows.

Large Woody Debris

Historically, many segments of the Willamette River were filled with snags (large wood) and fallen trees "too numerous to count" (Reports of Secretary of War 1875, in Sedell and Froggatt (1984). The USACE observed that a primary source of these snags was that trees toppled into the river from its banks during floods and were transported downstream (Benner and Sedell 1997). The snags often formed large jams and rafts of logs that created or cut off side channels, diverted flow, and formed gravel bars (Sedell and Froggatt 1984). All of these functions would have favored the creation and maintenance of complex, high-quality salmonid habitat.
For many years the USACE attempted to clear the Willamette River channel of large wood. Between 1870 and 1950, over 69,000 snags and overhanging trees were removed from the river, 90% of which were removed from highly complex channels found between Albany and Eugene (Sedell and Froggatt 1984). Inputs of large wood to the mainstem Willamette have been reduced by extensive riparian alterations along the river and in many tributary subbasins, as well as by elimination of wood delivery from watershed areas above dams. While no data quantifying large wood abundance is available for the present-day mainstem Willamette, the river no longer contains volumes of wood approaching those described by the USACE in 1875 surveys.

Channel Complexity, Off-channel Habitat & Floodplain Connectivity

Prior to development, complex channel features important to salmonids were created and maintained along the mainstem Willamette by the dynamic behavior of uncontrolled river processes including floods, gravel movement, large wood recruitment, erosion and sediment deposition (Hulse et al. 2002). Development of the Willamette Valley has modified these processes through flood control (with 13 major USACE dams), channel stabilization (by removing wood and constructing revetments), removal of large patches of riparian forest and their potential as wood sources, and gravel mining. The result has been channel simplification and reductions in the quantity and quality of key salmonid habitats: side channels, alcoves, and aquatic features on the river's floodplain (Hulse et al. 2002). These changes may also have had unfavorable effects on river temperatures, by increasing surfaces exposed to solar radiation (ODEQ 2006a) and by reducing important thermal refugia associated hyporheic exchange (Fernauld et al. 2001; ODEQ 2006a).

The historical Willamette River channel was very complex, frequently recruited and transported large wood, and dynamically changed its course in high-flow events unless constrained by adjacent topography. Beginning in the mid-1800s, however, efforts were made to improve the river for navigation, and the first federal program to improve the navigability of the Willamette began in 1870. The USACE removed large woody debris (as noted earlier) and began confining the river to fewer channels by dredging the main channel and blocking side channels (Benner and Sedell 1997). Over time, the USACE installed over 46 miles of revetments along the river and private entities constructed an additional 50 miles of such structures to maintain navigation, prevent riverbank erosion, or both. Combined, 25% of the mainstem Willamette has now been revetted on one or both sides. This understates the effect of these structures, however, because revetments are typically constructed along dynamic sections of river. Approximately 65% of all meander bends along the mainstem Willamette, those segments of the river most likely to change under natural conditions, have been stabilized with revetments (Hulse et al. 2002).

Flood control has exacerbated the loss of channel length and complexity caused along the Willamette by direct modifications like revetments, intentional channel blockages, and gravel removals because most changes in channel form occur during high flow events. Diminished high flows have reduced the river's access to its floodplain and the large wood still present in remaining patches of riparian forest. USACE dams now regulate about 65% of flow in the Willamette River at Harrisburg, and approximately 27% of runoff from the entire Willamette Basin passes through flood control reservoirs (USACE 1989a).

The mainstem Willamette River is today relatively simple and static compared to the complex, dynamic system present prior to development. During the period from 1850 to 1995, the total area of river channels and islands decreased from 41,000 acres to less than 23,000 acres and the total length of all channels decreased from 355 miles to 264 miles (Hulse et al. 2002). More than one half of the area of small floodplain tributaries and more than one-third of the alcoves and sloughs were lost by 1995 (Hulse et al. 2002). About half of these reductions in habitat complexity occurred between 1934 and 1995, a period influenced by the construction and operation of all 13 USACE flood control dams in the basin, and floodplain development that occurred after dam construction.

Losses of islands, alcoves and side channels, combined with extensive revetments, have reduced hyporheic (subsurface hydraulic) connectivity within the Willamette River. Fernauld et al. (2001) show that hyporheic flow can enter alcoves that are separated from the main river channel by 200 m gravel bars, and can have a strong influence on conditions in off-channel habitats. During the hottest time of the day during summer, the upper-most portion of some alcoves was 3.6 to 9^{o}F cooler than the main channel, most likely due to water emerging into the head of the alcove after flowing hyporheically (Hulse et al. 2002). Hyporheic connectivity is dependent on fresh, unconsolidated gravel, which has become limited in the upper Willamette River. Revetments directly prevent hyporheic connectivity (Fernauld et al. 2001), but also indirectly, as revetments hinder migration of the channel that is necessary for loose gravel to deposit and create conditions conducive to hyporheic flow.

Changes in habitat complexity, off-channel habitats, and floodplain connectivity have not been uniform along the Willamette. They have been pronounced along naturally unconfined river segments, particularly upriver from Albany (Figure 4.10-3), and more subtle where the river channel is naturally constrained by local topography, particularly below Newburg. This pattern would suggest that the mainstem rearing habitats of Chinook populations that spawn in tributary subbasins upriver from Albany, and particularly the McKenzie and Middle Fork Willamette spring Chinook, have been most affected by simplification of the mainstem Willamette.

Although significant seasonally high-quality rearing habitat still exists in some segments of the Willamette above Albany, what remains is a fraction of that once present. Though still the most complex section of the river, the Willamette above Albany has experienced a 45% reduction in active channel length, from 210 to 115 miles, since 1850 (Hulse et al. 2002). Also since 1850, the total area of islands and active channels within this river section has decreased from around 25,000 acres to about 8,000 acres. Approximately 70-80% of the island and side channel area, and 40% of the alcove area, were lost above Albany during this same period, with about half the loss occurring after 1932 (Hulse et al. 2002).

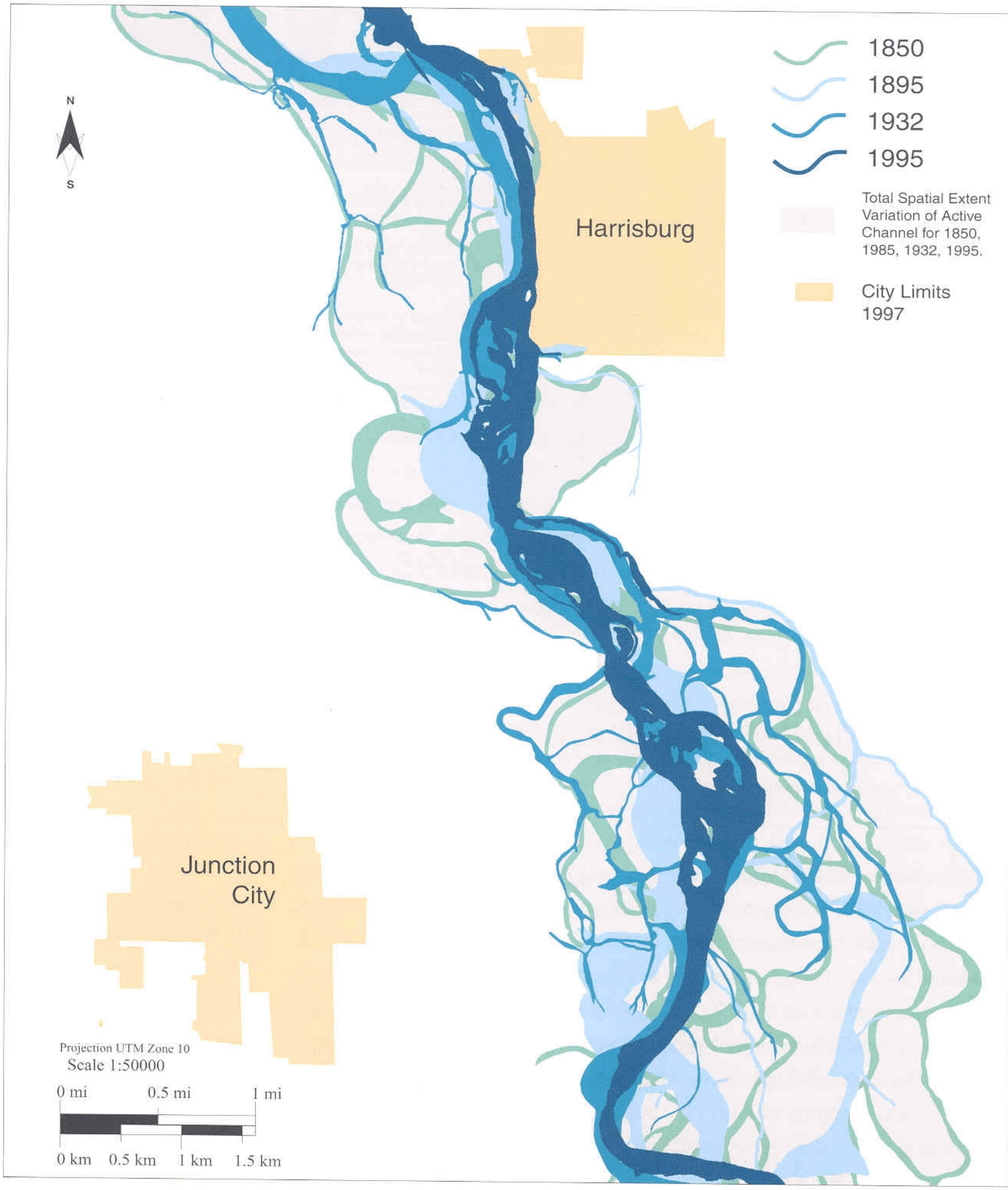

Figure 4.10-3 Changes in Willamette River channels in the Harrisburg area, upriver from Albany, between 1850 and 1995 (Hulse et al. 2002).

Riparian Reserves & Disturbance History

The general relationships between riparian vegetation, floodplain function, and the habitat requirements of UWR Chinook salmon and steelhead are described in Appendix E. Table 4.10-3 summarizes the status of riparian vegetation and floodplain function in the mainstem Willamette River under the environmental baseline, which is described in more detail below.

Pre-settlement vegetation along the Willamette River consisted primarily of bottomland forests containing black cottonwood, Oregon ash, Douglas fir, ponderosa pine, big-leaf maple, willow, and alder (Johannessen et al. 1970). The lateral extent of these forests depended on the width of the floodplain, but along reaches of the Willamette above Albany, they generally extended one to two miles on either side of the river. Bottomland forest near the confluence of the Santiam and Willamette rivers was approximately seven miles wide (Towle 1982). In 1850, hardwood forests bordered 68% the 276 river miles of channels length between Ross Island (below Willamette Falls) and Eugene, while mixed and coniferous forests were found along 21% of the river's length (Hulse et al. 2002).

In an intensive effort to improve the Willamette for navigation, the USACE cleared at least 31,450 trees from the banks of the Willamette from Albany to Eugene between 1870 and 1915, and cut additional wood to fuel steamboats used for clearing snags from the river. Larger-scale clearing of the Willamette's riparian forests began just before 1900, when softwoods were floated in rafts to paper mills in Oregon City (Nash 1904). By 1895, more than half of the bottomland hardwood forests had been converted to agriculture. Forests then continued to be cleared for agriculture well into the 20th century (Towle 1982) as large-scale irrigation systems became available and flood protection afforded by the newly-constructed Willamette Project reduced the risk of farming in the floodplain.

By 1990, riparian land uses were varied along the Willamette and had frequently altered or removed vegetation adjacent to the river. USACE characterizations of riparian vegetation while reconnoitering the river from a boat in 1850, 1895, 1932, and 1990, provide an indication of the changes that have taken place. Their accounts revealed that the greatest losses of forest have occurred along the Willamette River above Albany, where historically hardwood forests comprised 88% of streamside vegetation. As of 1990, 40% of the riverside area above Albany was occupied by agriculture and 9% by urban areas. Along the Willamette River from Albany to Newberg, agricultural and urban areas now border 40% of the river, where historically this area consisted of primarily hardwood forests interspersed with native grassland and mixed forests. Below Newberg, where almost 60% of the river passed through coniferous and mixed riparian forests in 1870, 50% of the riparian corridor had been converted to urban development or agricultural land.

Although substantially reduced in area and often in vigor, patches of cottonwood-dominated forest remain along the Willamette, particularly in those areas where they were once most extensive: along naturally unconstrained channels between Eugene and Newberg. Many of these patches started years ago as young trees that established themselves on exposed alluvial and floodplain surfaces after floods. Such natural establishment of these forests has been diminished by flood control.

During qualitative surveys of the river during 1995 and 1996, Dykaar and Wigington (2000) found few young cottonwoods and expressed concern that present levels of establishment are not sufficient to sustain riparian forests even at their presently diminished extent. This is something of substantial concern since cottonwoods are the bottomland species whose boles are large enough to make them important in providing big wood to the river. As cottonwood forests mature their understories fill with shade- tolerant species such as Oregon ash and big-leaf maple (Fierke 2002). Then, as they reach and pass maturity, live cottonwood trees and snags can serve as a source of in-channel wood if recruited to the river through channel migration or over-bank flooding. However, without the continued natural establishment of young cottonwoods that occurs with channel migration and overbank floods, existing cottonwoods near the river may senesce without replacement, leaving hardwood forests that are less capable of contributing big wood to the river. An additional concern is that non-native plant species, such as Himalayan blackberry and reed canarygrass, have invaded many riparian forests along the river and may hinder even the development of native understory species (Fierke 2002).

Land clearing for agricultural and urban development, construction of revetments, flood control, and invasive species have reduced the extent and health of riverside forests along the mainstem Willamette. This has contributed to reductions in the quantity and quality of rearing habitats for the river's juvenile salmonids by reducing inputs of wood to river's primary and secondary channels, limiting the complexity of available aquatic habitats, and contributing to elevated river temperatures by reducing levels of shade. Current riparian communities are far less capable than the historical floodplain forests at supplying valuable nutrients and organic matter during flood pulses, enhancing food sources for macro-invertebrates, and providing slow-water refugia for fish during flood events.

Summary

The installation of revetments, reduced magnitude and frequency of floods, direct channel modifications, development, reduced floodplain forest, reduced amounts of large wood, and gravel mining have significantly diminished both the quantity and quality of anadromous salmonid habitat in the mainstem Willamette River. Resultant decreases in channel complexity may have reduced thermal heterogeneity important to any remaining adult Chinook migrating up the river after water temperatures have risen to sub-optimal levels during late spring or summer. Reduced complexity has also affected the abundance and quality of mainstem summer rearing and/or over-wintering habitat for juvenile Chinook spawned in the river's tributaries. Such habitat includes woody debris jams, side channels, alcoves, areas of lowered velocity along channel margins, summer-time thermal refugia, and quiescent winter refugia on floodplains and in the lower-most reaches of valley floor tributaries.

4.10.4 Hatchery Programs

Interactions with hatchery fish exert key adverse effects on all UWR Chinook populations above Willamette Falls and two of four UWR Steelhead populations. The key threat to Chinook occurs at the adult spawner stage in the tributaries when hatchery fish interbreed with wild fish, and may reduce their fitness (productivity) through genetic introgression. Key threats to native steelhead occur at several juvenile life stages (competitive interactions) as well as at the adult spawner stage.

4.10.5 Fisheries

Chinook

UWR Chinook salmon returning to the Willamette River have supported many commercial and recreational fisheries, which contributed to their decline. Intentional harvest of natural-origin spring Chinook was, until recently, permitted. However, a Fisheries Management and Evaluation Plan that specifies a new harvest regime for wild UWR Chinook has been approved by NMFS under the ESA. Harvest management now focuses on using identifiable marks (fin clips) and selective fisheries to protect natural-origin stocks, with a cap of 15% for fishing-related mortality. The result has been a reduction in fishing-related mortality of wild fish to levels below the cap, and in the range of 8-12% (Figure 4.10-4, ODFW 2008c). Selective fisheries are helping to conserve the wild population while allowing harvest of more abundant adult hatchery-origin Chinook that were released as smolts into the Willamette's tributaries.

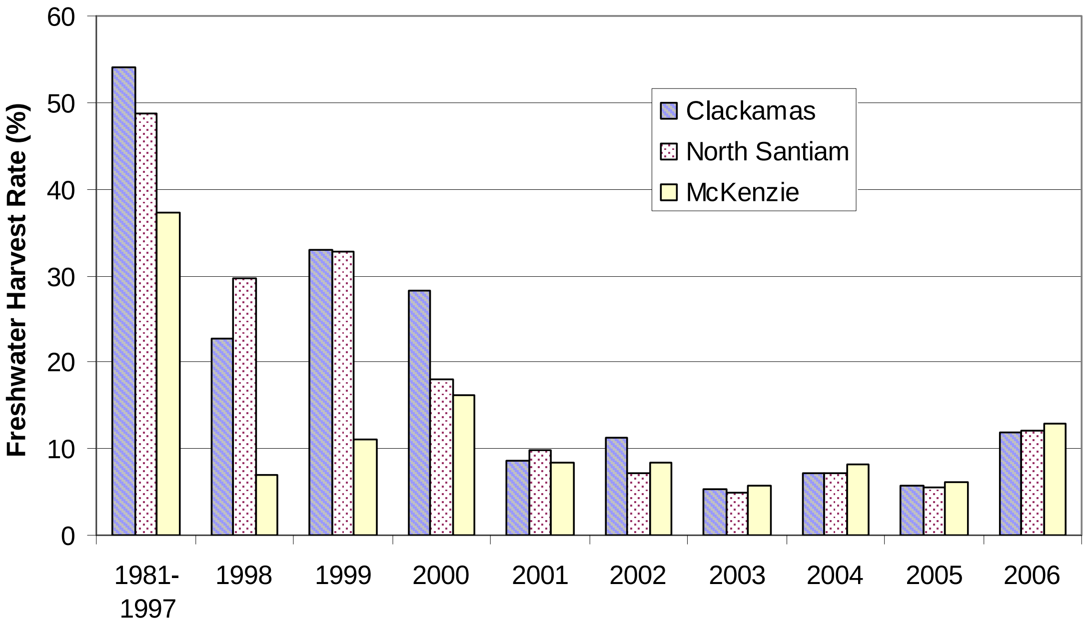

Figure 4.10-4 Harvest rates of wild UWR Chinook in freshwater commercial and sport fisheries. Data from ODFW (2008c).

Steelhead

Fishing-related mortality of wild UWR Steelhead is held to low levels by selective fisheries that allow harvest only of hatchery-origin steelhead marked with a clipped adipose fin. Chilcote (2007) estimates that recent levels of incidental mortality on these populations have averaged 7%.

4.10.6 Status of PCEs of Designated Critical Habitat and Factors Affecting Those PCEs along the Mainstem Willamette

Although the WLCTRT (2003) found no evidence of a historical demographically independent population of UWR Chinook or UWR Steelhead that spawned primarily in the mainstem Willamette, NMFS designated the river as Critical Habitat because of its importance as both a migratory corridor and juvenile rearing area for populations in the river's tributaries (NMFS

2005g). The mainstem Willamette River passes through three different subbasins, within each of which Critical Habitat has been identified by NMFS (2005d). The Lower Willamette subbasin includes the mainstem from its confluence with the Columbia River to Willamette Falls (RM 0.0 to RM 26.6). The Middle Willamette subbasin includes the mainstem from Willamette Falls upriver to the confluence of the Luckiamute River (RM 26.6 to RM 107.5). The Upper Willamette subbasin includes the mainstem from the Luckiamute River confluence up to the confluence of the Middle and Coast forks of the Willamette (RM 107.5 to RM 187.0). NMFS determined that the following occupied areas of habitat associated with the mainstem Willamette River contain PCEs (as described below) for UWR Chinook salmon ESU and UWR steelhead (NMFS 2005g):

UWR Chinook salmon in the Upper Willamette Subbasin, excluding Westside Tributaries (see section 4.9) and the Calapooia system (section 4.4)

- There are 0 miles of PCEs for spawning/rearing, 79.9 miles for rearing/migration, and 0 miles for migration/presence in the Upper Willamette Subbasin. Areas included are the mainstem Willamette, its floodplain, and small floodplain tributaries.
- The upper mainstem Willamette is an important rearing area and migration route for UWR Chinook, but the watersheds within which it is embedded were given a low rating.
- Bank protection measures in the mainstem Willamette associated with USACE activities total 175,387 linear feet (33.2 miles) between RM 111.1 and RM 182.6, with 66,559 feet (12.6 miles) on the right bank, and 108,828 feet (20.6 miles) on the left bank (USACE 2000).

UWR Chinook salmon in the Middle Willamette Subbasin

- There are 0 miles of PCEs for spawning/rearing, 158.3 miles for rearing/migration, and 0 miles for migration/presence in the Middle Willamette Subbasin. This subbasin includes habitat within the mainstem and multiple small tributaries.
- All watersheds evaluated in the Middle Willamette River subbasin were assigned a low rating.
- Bank protection measures associated with USACE activities total 71,469 linear feet (13.5 miles) between RM 59.6 and RM 104.7, with 37,201 feet (7.04 miles) on the right bank, and 34,268 (6.5 miles) on the left bank (USACE 2000).

UWR Chinook salmon in the Lower Willamette Subbasin

- There are 0 miles of PCEs for spawning/rearing, 46.5 miles for rearing/migration, and 0 miles for migration/presence in the Lower Willamette Subbasin. This subbasin includes the mainstem Willamette and the following tributaries: Johnson Creek, Scappoose Creek, and the Columbia River Slough.
- All 3 watersheds were assigned a high rating because rearing and migration through these areas are considered highly essential for ESU conservation. (NMFS 2005g).

UWR Steelhead in the Upper Willamette Subbasin, excluding Westside Tributaries and the Calapooia system

- There are 0 miles of PCEs for spawning / rearing, 12 miles for rearing/migration, and 0 miles for migration/presence in the Upper Willamette Subbasin. This includes mainstem habitat between the Calapooia and Luckiamute confluences.

- The watershed within which the segment of the mainstem noted above is embedded was assigned a medium rating.
- Bank protection measures in the Mainstem Willamette associated with USACE activities total 175,387 linear feet (33.2 miles) between RM 111.1 and RM 182.6, with 66,559 feet (12.6 miles) on the right bank, and 108,828 feet (20.6 miles) on the left bank (USACE 2000). Some of these altered banks are upriver from the habitat designated as critical for UWR Steelhead.

UWR Steelhead in the Middle Willamette Subbasin

- There are 35.8 miles of PCEs for spawning / rearing, 140.7 miles for rearing/migration, and 0 miles for migration/presence in the Middle Willamette Subbasin. This subbasin includes the mainstem Willamette and several small tributaries.
- Within the 4 watersheds evaluated in the Middle Willamette River subbasin, all 4 were assigned a low rating.
- Bank protection measures associated with USACE activities total 71,469 linear feet (13.5 miles) between RM 59.6 and RM 104.7, with 37,201 feet (7.04 miles) on the right bank, and 34,268 (6.5 miles) on the left bank (USACE 2000).

UWR Steelhead in the Lower Willamette Subbasin

- There are 0 miles of PCEs for spawning / rearing, 46.5 miles for rearing/migration, and 0 miles for migration/presence in the Lower Willamette Subbasin. This subbasin includes the mainstem Willamette and the following tributaries: Johnson Creek, Scappoose Creek, and the Columbia River Slough.
- All 3 watersheds were assigned a high rating because rearing and migration through these areas are considered highly essential for ESU conservation.

NMFS (2005g) identified the key management activities that affect the PCEs identified above. These activities include agriculture, channel modifications/diking, road building and maintenance, urbanization, and wetland loss and removal.

Table 4.10-3 summarizes the condition of PCEs associated with the mainstem Willamette River. Many of the habitat indicators are not in a condition suitable for salmon and steelhead conservation. In most instances, this is the result of past or ongoing operations of the Willamette Project, USACE alterations of the river channel, or the cumulative effects of other human activities (e.g., development, agriculture, and logging).

Table 4.10-3 Critical habitat primary constituent elements (PCEs) and associated pathways, indicators, current conditions, and limiting factors for ESA-listed anadromous salmonids in the Mainstem Willamette River under the environmental baseline.

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater migration corridors	Habitat Access	Physical Barriers	*Willamette Falls as a Barrier to Migration* Willamette Falls (RM 26.6) is a natural barrier that has always restricted fish passage during low flows; however, constructed ladders have likely improved passage during low flow periods. Navigation locks built in 1873 allowed some upstream fish passage; first crude rock fishway built at Willamette Falls in mid-1880s to early 1890s Falls developed for hydroelectric production in 1891 with as many as 52 turbines in operation at one time; juvenile Chinook turbine mortality rates are 7.7%-100% Sullivan Plant was closed during the downstream migration in the mid-1970s and 1980s; with structural improvements to the bypass in 1991, Sullivan Plant operates year round. Currently, downstream passage survival is above 90% through the Sullivan Plant and anticipated to be at least than 97% over the Willamette Falls Dam.	Natural condition Privately owned navigation lock Private hydroelectric development

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Late winter and spring flow reductions may reduce the survival of outmigrating winter steelhead and spring Chinook smolts Spring flow reductions may reduce delays adult Chinook salmon experience at the Willamette Falls hydro project during high flows Increased flows in summer may benefit juvenile Chinook by increasing rearing habitat area for rearing juveniles and by increasing the heat capacity of the system Frequency of channel-forming and over-bank flows has been greatly reduced Human-caused increases in the rate of flow fluctuations are not a significant concern	Late winter and spring refill operations at USACE's Willamette Project reservoirs USACE flow augmentation operations at Willamette Project reservoirs (typ. July - Aug.) Flood control operations at the 13 USACE Willamette Project dams reduce the magnitude and frequency of peak flows in the mainstem
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	ODEQ 2004/2006 Integrated Report indicates that temperatures in the mainstem Willamette (RM 50.6 to 186.5) exceeded criteria for year-round salmon and trout rearing and migration, and for salmon and steelhead spawning for Oct 15 to May 15. ODEQ 2004/2006 Integrated Report indicates temperatures in the mainstem Willamette (RM 0.0 to 50.6) exceeded criteria for year-round salmon and steelhead migration corridors. Water stored in Willamette Project reservoirs is released during late July and August to protect mainstem water quality (including temperature)	Land use practices throughout the basin: Timber harvest Agriculture Urbanization USACE operations at the 13 Willamette Project reservoirs

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	ODEQ 2004/2006 Integrated Report database does not indicate exceedences of water quality criteria for turbidity	N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	ODEQ 2004/2006 Integrated Report database indicates the following exceedences of water quality criteria for the protection of anadromous fish passage: DDT – 2 out of 7 water column samples at RM 12.7 exceeded the criterion of 0.000024 µg/L - Polynuclear aromatic hydrocarbons (PAH) at RM 6 – 35-day average of 52,900 pg/L exceeded the criterion of 2,800 pg/L ODEQ 2004/2006 Integrated Report does not indicate exceedences of water quality criteria for excess nutrients	Pesticide applications: Agriculture Transportation Rural development N/A
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	Dissolved oxygen concentrations in the mainstem Willamette River (RM 151 to 141.6) have fluctuated below the ODEQ's numerical criteria. Dissolved oxygen levels in the mainstem Willamette River have increased since 1945, as evidenced by increased numbers of fish species that are relatively sensitive to low dissolved oxygen levels	Periphyton (attached algae) respiration. Flow augmentation from USACE reservoirs Basin-wide secondary sewage treatment

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	There is no information indicating that total dissolved gas concentrations in the mainstem Willamette River have exceeded 110% of saturation	N/A
Freshwater spawning sites	Habitat Elements	Substrate	Mainstem Willamette is downcutting at several gage locations Sediment budget is not balanced due to extraction from gravel mining, retention in reservoirs, and lack of recruitment from eroding banks Substrate is probably armored	USACE reservoirs trap sediment and large wood from headwaters USACE operates flood control dams to reduce the magnitude and frequency of peak flows USACE and private revetments USACE channel straightening Extensive in-stream and floodplain gravel mining
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Lack of large wood in main channel and side channels	USACE removes large wood from reservoirs USACE removed snags in lower river for navigation Inadequate recruitment from Willamette riparian forests Inadequate recruitment from tributaries

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Simplification of the river channel has resulted in losses of pools and pool quality	USACE dams and reservoirs affect inputs and transport of sediment and wood. USACE and private revetments USACE channel straightening Agricultural and urban development of the valley floor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Major losses of channel complexity, side channels, backwaters, and other features of importance to salmonids as a consequence of stream cleaning, construction of revetments, flood-control, altered riparian vegetation, reduced inputs of large wood, and floodplain development.	USACE reservoirs trap sediment and large wood from upland areas USACE operates flood control dams to reduce the magnitude and frequency of peak flows USACE and private revetments USACE channel straightening Agricultural and urban development of the valley floor
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Width/Depth Ratio	The river is less dynamic and has fewer multi-threaded channels due to historical alterations, construction of revetments, flood-control, altered riparian vegetation, reduced inputs of sediment and large wood, and floodplain development.	USACE reservoirs trap sediment and large wood from upland areas USACE operates flood control dams to reduce the magnitude and frequency of peak flows USACE and private revetments USACE channel straightening Agricultural and urban development of the valley floor

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	46 miles of USACE revetments and 50 miles of private revetments along the mainstem Willamette prevent lateral channel migration 65% of outer bends of meanders revetted Channel length in 1990 reduced to only 20-30% of channel length in 1850 Alcove and island area reduced to 20%- 30% of that present in 1850 River channel form does not change frequently, and new islands and gravel bars seldom form	USACE operates flood control dams to reduce the magnitude and frequency of peak flows USACE reservoirs trap sediment and large wood from headwaters USACE channel straightening USACE and private revetments USACE removes large wood from reservoirs Development of floodplain land
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain Connectivity	Floodplain is not frequently inundated, with less over-bank flow and side channel connectivity Reduced nutrient exchange, reduced sediment exchange, reduced flood refugia for fish, and reduced establishment of new riparian forests	USACE blockage of side channels and channelization for navigation USACE operation of flood control dams reduces the magnitude and frequency of peak flows USACE and private revetments Levees

PCE	Pathway	Indicator	Condition	Limiting Factors
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Disturbance History	Prairie and oak savanna habitat is rare within the Willamette Valley foothills Lower watershed contains extensive agricultural, urban, and residential development Agriculture and development constitute almost 60% of the Willamette Valley lowland vegetation	Conversion to agricultural, urban, residential, industrial, and rural uses
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Area of riparian forest along the mainstem Willamette in 1990 is 75-90% less than in 1850 Many remaining patches of floodplain forest are interspersed with agriculture Low large wood recruitment potential Few continuous large patches of riparian forest Many forests contain non-native Himalayan blackberry and reed canary grass that hinder development of young cottonwood forests. Prairie and oak savanna habitat is rare within the Willamette Valley foothills	Clearing for navigation, agriculture, or development USACE and private revetments USACE operation of flood control dams alters the hydrologic regime Timber harvest Conversion to agricultural, urban, residential, industrial, and rural uses

Section 4.11
Lower Columbia River, Estuary & Coastal Ocean Baseline

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4.11 LOWER COLUMBIA RIVER, ESTUARY, & COASTAL OCEAN

The Columbia River is the largest in the Pacific Northwest and the fourth largest in the United States. At its confluence with the Willamette River near Portland, Oregon, the river carries an average annual flow of about 190,000 cfs. The Willamette River contributes another 34,000 cfs, about 15 percent of total Columbia River flow.

All 13 listed species of ESA-listed Columbia River basin salmonids (see Table 3-1) occupy the lower Columbia River during some portion of their life cycle, primarily during their juvenile and adult migrations. The estuary is also occupied by the southern DPS of North American green sturgeon (*Acipenser medirostris*), which is listed as threatened. Southern Resident killer whales are found throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia. Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000). To date, there is no evidence that Southern Residents travel further than 50 km offshore (Ford et al. 2005).

Recent investigations using Interior Columbia Basin Chinook and steelhead have shown that juvenile salmon survival below Bonneville Dam is a strong determinant of year-class strength. Several known factors contribute to this effect, including bird, fish, and pinniped predation and near-shore ocean characteristics. The latter are presumed to be related to the influence of ocean conditions on the availability of prey and as habitat for marine predators at the time of ocean entry.

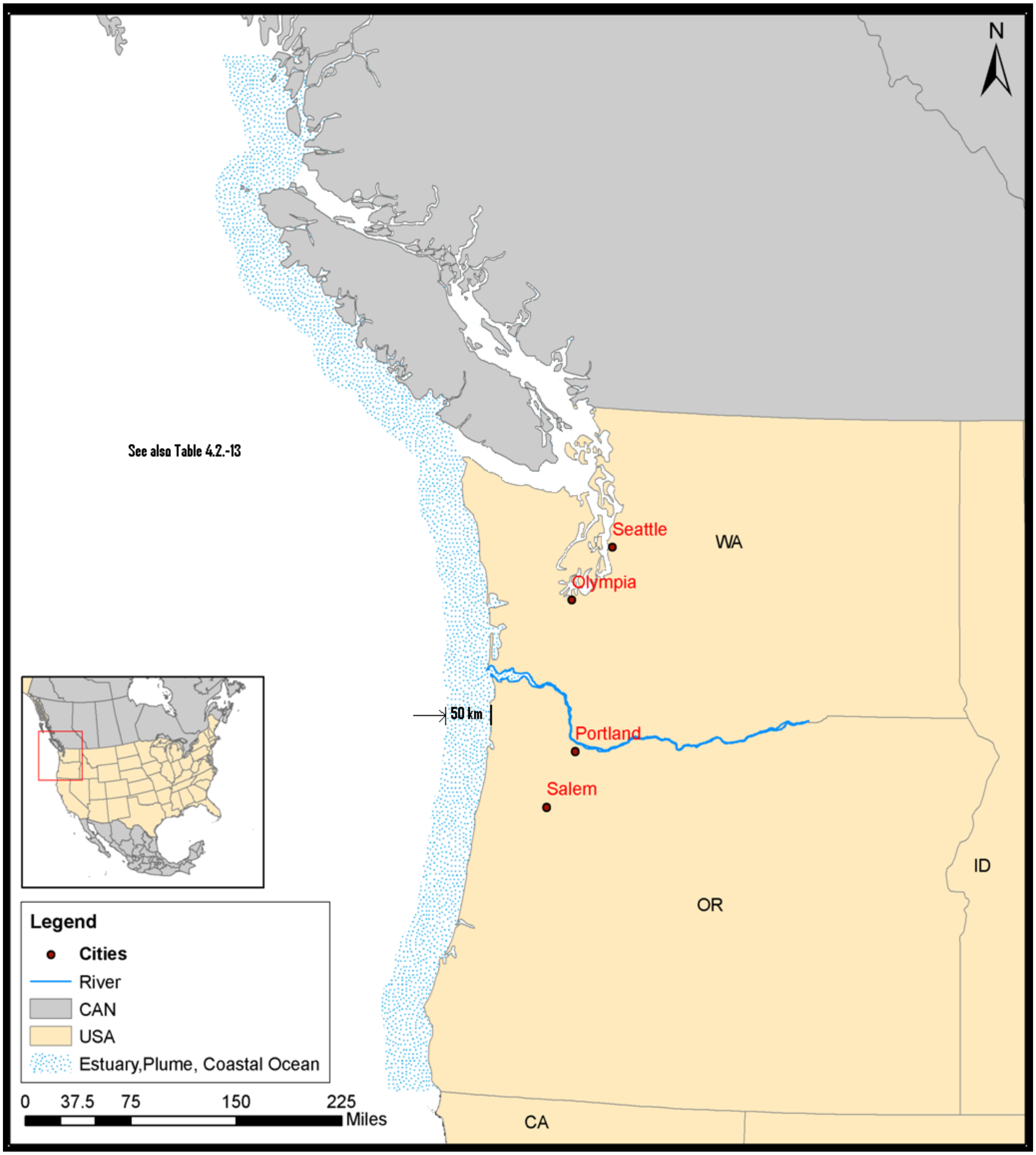


Figure 4.11-1 Map of Coastal Ocean

4.11.1 Status of Habitat in the Lower Columbia River, Estuary, and Coastal Ocean

Habitat in the lower Columbia River, estuary, and plume has been affected over the past 60 years by water development, including operations at mainstem Columbia River hydrosystem projects and by operations at the multipurpose storage projects both in the upper Columbia and Willamette basin. With the loss of low velocity, shallow water habitats, the mainstem reach of the lower Columbia River has been reduced primarily to a single channel. The river has been cut off from the tidal floodplain by dikes, revetments, and flood control operations, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large woody debris in the mainstem has been greatly reduced. Much of the remaining habitat continues to be affected by flow fluctuations associated with reservoir water management for flood control, irrigation, and other purposes.

Large multipurpose storage projects, developed in both Canada and the United States, have altered the seasonal runoff pattern and volume of flow into the estuary. Recent model studies indicate that the volume and timing of water and sediment delivery to the estuary have changed since the late 1880s due to hydrosystem operation, even after the effects of climate change and irrigation withdrawals are taken into account (Bottom et al. 2000). Compared with the 1880s, current operations:

- Deliver more water to the estuary during winter (October through April) and less water during spring and summer
- Reduce the peak spring freshet by more than 40% and reduce total freshet-season flow volume by about 30%
- Lengthen the period of the freshet and move the peak flow earlier (by pre-releasing stored water for flood control, a need heightened by recent global climate change)
- Greatly increase fall-winter minimum flows

In addition, model studies indicate that the hydrosystem and climate change together have decreased suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more. Over-bank flow events, important to habitat diversity, have become rare – in part because flow management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the “bankfull” flow level (from about 643,000 to 857,000 cfs). The dynamics of estuarine habitat have changed in other ways relative to flow. The availability of shallow (between 4-in and 6.5-ft depth), low-velocity (less than 1 ft/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the estuary’s absorption capacity for increasing water depth with increasing flow appears to have declined.

Depending on the season and river flow, the Columbia River plume may extend hundreds of miles into the Pacific Ocean. The plume appears to be an important habitat for juvenile salmonids, particularly during the first month or two of ocean residence. Ongoing studies show that nutrient concentrations in the plume are similar to those associated with upwelled nearshore waters, thus the plume may provide an important nutrient source for juvenile salmonids and other species. Coho salmon appear to have a preference for low salinity surface waters, as the abundance and distribution of juveniles are higher and more concentrated in the Columbia River plume compared to adjacent, more saline waters (Jay 2002). What is not known is how Columbia River flows affect the structure of the plume during outmigration periods, and whether critical threshold flows are needed. Ongoing research is documenting important relationships between juvenile salmon growth and survival during this stage of their life history (Casillas 2002).

4.11.1.1 Predator/Prey Interactions in the Lower Columbia River, Estuary & Coastal Ocean

4.11.1.1.1 Piscivorous Birds

Increasing populations of piscivorous birds (primarily Caspian terns and double-crested cormorants), nesting on islands in the Columbia River estuary, have annually consumed millions of migrating juvenile salmonids (Roby et al. 1998; IMST 1998; Johnson et al. 1999). Anthropogenic changes in the Columbia River Basin appear to have facilitated increases in populations of these colonial waterbirds (Roby et al. 1998). Until 1999, the largest recorded colony of Caspian terns in the world (Roby et al. 1998) occupied an island created by dredging and maintaining a navigation channel in the Columbia River estuary. The terns fed on large numbers of migrating juvenile salmon and steelhead as they moved through the estuary (Table 1 in NMFS 2002). The Corps began to move the tern colony to a naturally-formed island in the lower estuary (East Sand Island) in 1999 in an effort to reduce the number of juvenile salmonids consumed. This strategy has worked, reducing the number of smolts consumed per year from greater than 12 to approximately 5.4 million. Under the RPA for the 2008 FCRPS Biological Opinion (NMFS 2008a), the Action Agencies are relocating the tern colony to sites outside the Columbia River estuary by 2010, which is expected to reduce predation rates even further. However, the double-crested cormorant colony has increased in size in the last decade and these predators now consume as many smolts as the terns. Under the FCRPS RPA, the Action Agencies will also develop a management plan for double-crested cormorants, although implementation is uncertain.

4.11.1.1.2 Northern Pikeminnow

Although northern pikeminnow (*Ptychocheilus oregonensis*) is a native species that is a natural predator of juvenile salmonids, development of the Columbia River hydropower system has likely increased levels of predation. Northern pikeminnow predation throughout the Columbia and Snake Rivers was indexed in 1990-1993 based on electrofishing catch rates of predators and the occurrence of salmonids in predator stomachs relative to estimates in John Day Reservoir (Ward et al. 1995). Northern pikeminnow abundance was estimated to total 1.8 million, and daily consumption rates averaged 0.06 salmonids per predator (Beamesderfer et al. 1996).

Beamesderfer et al. (1996) estimates that over 16 million total salmonids were consumed annually in the mainstem Columbia and Snake Rivers prior to initiation of the Northern Pikeminnow Management Program (NPMP see below). Total system-wide impacts are concentrated in the lower Columbia River from The Dalles Reservoir downstream, where approximately 13 million of the 16.4 million total salmonids are estimated to have been consumed by northern pikeminnow. This estimated predation loss is 8% of the approximately 200 million hatchery and wild juvenile salmonid migrants in the system.

Northern Pikeminnow Management Program (NPMP)

Predator control fisheries have been implemented in the Columbia Basin since 1990 to harvest northern pikeminnow with an annual exploitation rate goal of 10-20%, needed to obtain up to a 50% reduction in smolts consumed by pikeminnow (Rieman et al. 1991). The NPMP is a multi-year, ongoing effort funded by BPA to reduce piscivorous predation on juvenile salmon, primarily through public, angler-driven, system-wide removals of predator-sized northern pikeminnow. From 1991 to 1996, three fisheries (sport-reward, dam angling, and gill net) harvested approximately 1.1 million northern pikeminnows greater than or equal to 250 mm fork length. Total exploitation averaged 12.0% (range: 8.1 to 15.5%) for 1991 to 1996 (Section 6.2.7.1 in NMFS 2000b).

Since the program's inception in 1990, the NPMP's monetary incentive to harvest northern pikeminnow has motivated sports fishermen to remove over two million northern pikeminnow throughout the system. This has reduced predation mortality by an estimated 25% (Friesen and Ward 1999), which is estimated to equate to approximately 4 million fewer juvenile salmonids consumed by pikeminnow each year. Currently, the annual harvest rate ranges approximately between 8 and 16% of the northern pikeminnow that qualify in size but has averaged approximately 12% in the last number of years. In 2001 and again in 2004, BPA increased the reward, which led to increases in both catch and exploitation. Under the 2008 FCRPS RPA (NMFS 2008a), the expanded Northern Pikeminnow (*Ptychocheilus oregonensis*)-Management Program will continue for ten years, which will benefit all 13 salmonid species.

4.11.1.2 Water Quantity/Hydrograph

Based on a review of available streamflow data, the Willamette River provides about 4 to 29% (averaging approximately 15%) of total average monthly Columbia River flow at Portland, Oregon (Table 4.11-1). The Willamette River's total contribution is highest during fall and winter and lowest during summer.

Table 4.11-1 Average monthly flows in the Columbia and Willamette rivers and the percent contribution of the latter to total Columbia River flow.

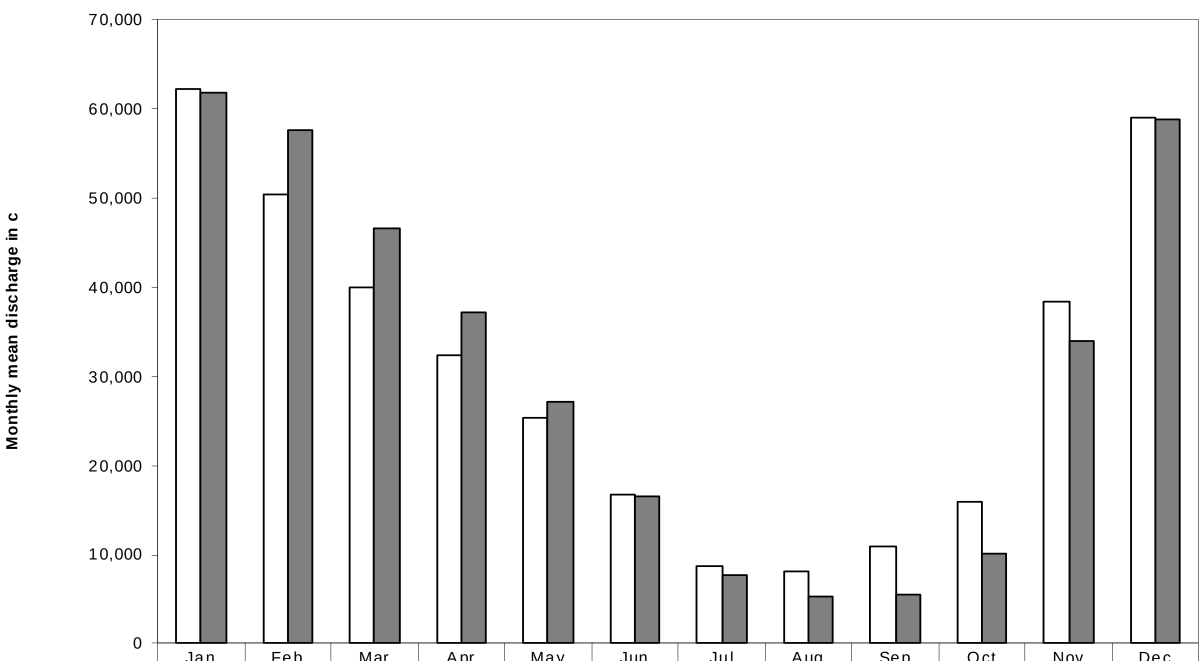
Month	Columbia River above Willamette River Confluence (cfs)[1]	Willamette River at Portland (cfs)[2]	Columbia River below Willamette River Confluence (cfs)	Willamette River % of Columbia River Flow
January	195973	68539	264512	25.9%
February	185478	62136	247614	25.1%
March	184371	51143	235514	21.7%
April	233297	41326	274623	15.0%
May	297903	30253	328156	9.2%
June	312666	18562	331228	5.6%
July	213825	8791	222616	3.9%
August	150469	6110	156579	3.9%
September	106569	6475	113044	5.7%
October	114821	11148	125969	8.8%
November	137257	37408	174665	21.4%
December	159528	64318	223846	28.7%

Notes:

1. Combined average monthly flow from simulated Federal Columbia River Power System operations under the 2008 biological opinion and twice the monthly average flow of the Sandy River below Bull Run River, USGS Station No. 14142500 (72-year period of record [1911-1966 and 1985-2000]).
2. Simulated monthly average Willamette River discharge based on a 70-year simulation of current operations.

Willamette Project operations have affected flow in the lower Columbia River in three ways (Figure 4.11-2):

- Flow in the Columbia River downstream from its confluence with the Willamette River has increased during summer (July and August), when water is released from Project reservoirs to maintain water quality in the Willamette, and has increased by a larger amount during fall (September through November), when project reservoirs are evacuated to provide storage space for fall and winter floods
- Flow in the Columbia has decreased by a small amount during late-winter through spring (February through May), when water is stored in Project reservoirs, to bring them back up to summer elevations
- Flow in the Columbia has decreased episodically during fall and winter, when peak flows generated by storms or rain-on-snow are stored in Project reservoirs (i.e., to reduce the risk of downstream flooding), followed by increases, as the stored water is released to provide storage for future flood events.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Regulated	62,233	50,421	39,994	32,377	25,249	16,829	8,772	8,218	10,918	15,918	38,468	58,929
Unregulated	61,849	57,636	46,643	37,116	27,223	16,502	7,781	5,289	5,561	10,058	33,968	58,808

Figure 4.11-2 Simulated monthly average Willamette River discharge at Oregon City, Oregon before (unregulated) and after (regulated) construction of the 13 USACE multipurpose dams. Source: Donner 2008.

During February through May, Willamette Project operations have modified (i.e., decreased) average monthly flows in the lower Columbia River by less than 3% or less compared to the pre-project period (Table 4.11-2). Average project effects are larger (flows increased by up to 5%) in September through December, the natural low flow season in the lower Columbia River.

Table 4.11-2 Average monthly Columbia River flows and the estimated change in discharge caused by Willamette Project operations, measured at Portland below the mouth of the Willamette River.

	Columbia River Flow below Mouth of Willamette River (cfs)	Change in Willamette River Flow Caused by Willamette Project Operations (cfs) [1]	Effect of Willamette Project Operations on Columbia River Flows (percent)
January	264,512	384	0.15%
February	247,614	-7,215	-2.91%
March	235,514	-6,648	-2.82%
April	274,623	-4,739	-1.73%
May	328,156	-1,974	-0.60%
June	331,228	326	0.10%
July	222,616	991	0.45%
August	156,579	2,929	1.87%
September	113,044	5,357	4.74%
October	125,969	5,860	4.65%
November	174,665	4,500	2.58%
December	223,846	121	0.05%

Notes:
1 Effects of past project operations are derived from operations simulation over a 70-year record. Source: Donner 2008.

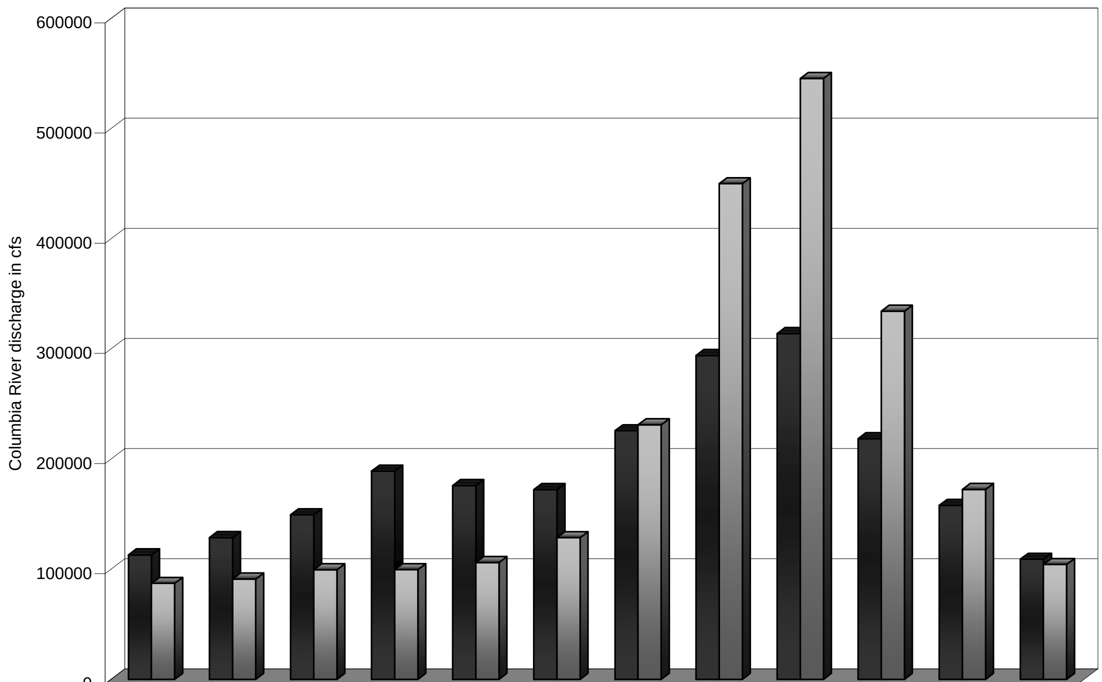
The Willamette Project's relative influence on Columbia River flows diminish in a downstream direction as other tributaries, especially the Cowlitz and Lewis Rivers, contribute additional flow. Estimating flow at the mouth of the Columbia River near Astoria, Oregon, as the flow immediately downstream from the Willamette-Columbia confluence plus flows in the Lewis and Cowlitz rivers plus 10% for local accretion, past Willamette Project operations have modified Columbia River flows by an average of about 2% (Table 4.11-3).

Table 4.11-3 Average monthly Columbia River flows and the estimated change in discharge caused by Willamette Project operations, measured at Quincy, Oregon (USGS Gage 14246900)

Month	Columbia River Flow below Mouth of Willamette River (cfs)	Cowlitz and Lewis and Local Tributary Contributions (cfs)	Columbia River Total Flow at Mouth (cfs)	Change in Willamette River Flow Caused by Willamette Project Operations[1] (cfs)	Effect of Willamette Project Operations on Lower Columbia River Flows
January	264512	23879	288391	384	0.13%
February	247614	22193	269807	-7215	-2.67%
March	235514	18593	254107	-6648	-2.62%
April	274623	17159	291782	-4739	-1.62%
May	328156	17261	345417	-1974	-0.57%
June	331228	14736	345964	326	0.09%
July	222616	8139	230755	991	0.43%
August	156579	4655	161234	2929	1.82%
September	113044	5141	118185	5357	4.53%
October	125969	8578	134547	5860	4.36%
November	174665	18913	193579	4500	2.32%
December	223846	25777	249624	121	0.05%

Note: The hydrologic effects of the Project were estimated by comparing hydrologic records before and after the Project was developed. Because post-development conditions were somewhat wetter (due to increased precipitation) than pre-development conditions, the apparent increase in fall and early winter flows at the Quincy gage (e.g., December flows increased by 8.2%) may be over-estimated.

The Columbia River is highly developed for water use, hydropower production, and navigation. Lower Columbia River flows have been altered by operations at storage reservoirs located upstream from the mouth of the Willamette. With a combined active storage of about 50 Maf, these upstream reservoirs profoundly affect the seasonal hydrology of the Columbia River. Many of these reservoirs are drafted during the fall and winter to provide downstream flood protection and to generate energy during the high-load winter months (October through March), thereby increasing flows in the lower Columbia River (Figure 4.11-3). Refilling these reservoirs during the spring substantially decreases spring flows in the lower Columbia. Although a substantial amount of consumptive water use occurs during the summer months, this effect is largely offset by reservoir drafting to serve that demand. Combining the effects of operations upstream from the mouth of the Willamette with those of Willamette Project reservoirs, flows in the lower Columbia River have increased (i.e., compared to the predevelopment period) by 9% to 51% during September through March (Table 4.11-4). Flows have been reduced by 4% to 41% from April through August.[1]



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 4.11-3 Simulated mean monthly Columbia River flows at Bonneville Dam under current conditions and flows that would have occurred without water development (natural). Source: Current - HYDSIM model run FRIII07Final2008BiOp, Natural – USBR 1998.

[1] Individual year effects may be greater or less than these long-term averages.

Table 4.11-4 Comparison of mean monthly Columbia River discharge downstream from the Willamette River confluence under pre-development and current conditions

Month	Pre-development Columbia River Flow (cfs)	Current Columbia River Flow (cfs)	Change in Columbia River Flow Since Development (cfs)	% Change in Columbia River Flows
January	175013	264977	89964	51%
February	174969	237641	62672	36%
March	185753	222675	36922	20%
April	278989	268892	-10097	-4%
May	485934	327869	-158065	-33%
June	567728	336423	-231305	-41%
July	344655	229930	-114724	-33%
August	179536	167970	-11566	-6%
September	111849	121915	10067	9%
October	100591	132353	31762	32%
November	134723	176836	42112	31%
December	171302	221437	50136	29%

Note:
Data are from several sources. Pre-development flows are the sum of simulated pre-development Columbia River flows at Bonneville Dam for the period of record from 1929 to 1978 (USBR 1999), two times Sandy River flows from 1910 to 2000 (USGS Station No. 14142500), simulated Willamette River flows at Portland, Oregon from 1937 to 2004, and Clackamas River flows (USGS Station No.14211010). Current flows are the sum of simulated flows under the current level of development and with current operations at Bonneville Dam from 1929 through 1998, two times Sandy River flows for the period of record 1910 through 2000 (USGS Station No. 14142500), simulated Willamette River flows at Portland, Oregon from 1937 to 2004, and Clackamas River flows (USGS Station No.14211010).

The effects of these changes in the hydrologic environment on anadromous fish are discussed below.

4.11.1.3 Water Quality

Water quality characteristics of the lower Columbia River are affected by an array of land and water use developments. Water quality characteristics of particular concern are: water temperature, turbidity, total dissolved gas, and chemical pollutants.

Water Temperature
Water development influences water temperatures through storage, diversion, and irrigation return flows. These changes in water temperatures have significant implications for anadromous fish survival.

Comparisons of long term temperature monitoring in the migration corridor before and after impoundment reveal a fundamental change in the thermal regime of the Columbia River. Using historical flows and environmental records for the 35 year period from 1960 to 1995, one recent study compared water temperature records in the lower Snake River with and without the federal mainstem dams (Perkins and Richmond 2001). There are three notable differences between the current temperature regime and the temperature regime of the unimpounded Columbia River:

- Maximum summer water temperatures have been reduced slightly,
- Water temperature variability has decreased, and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall. (This latter phenomenon is termed thermal inertia, see Section 4.1.1.3)

Biological Effects
High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmon to stop or delay their migrations. Warm water temperatures also increase the metabolic demands and thus the foraging rates of predatory fish, thereby increasing consumption of smolts. Though the duration and magnitude of high water temperatures in the migration corridor is generally less under current, developed conditions than prior to water development, some juvenile fish are exposed to these conditions for a longer period of time due to the substantial increase in travel time caused by FCRPS and Upper Snake operations (NMFS 2008b).

Global warming has increased average annual Columbia Basin air temperatures by about 1 degree C over the past century and water temperatures have been affected similarly (ISAB 2007). The influence of this and other large-scale environmental variations are discussed in Section 4.1.

Turbidity
Flow regulation and the settling of particulates in upstream reservoirs reduce turbidity in the lower Columbia River. Reduced turbidity can increase predator success through improved prey detection, increasing the susceptibility smolts to predation. Predation is a substantial contributor to juvenile salmon mortality throughout the Columbia River migration corridor.

Total Dissolved Gas
Spill at mainstem dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated total dissolved gas (TDG) conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1 and 2% when TDG concentrations in the portion of the water column occupied by migrating fish do not exceed 120% of saturation. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms.

High TDG conditions diminish with time and in a downstream direction from the point of creation. TDG conditions in the lower Columbia River are strongly affected by operations at hydroelectric projects on the Columbia River, principally Bonneville Dam, whereas operation of the Willamette Project has negligible effect on TDG conditions in this part of the action area. Since the late 1980s, substantial efforts have been made to limit the magnitude and duration of adverse TDG conditions in the lower Columbia River migratory corridor and additional measures will be taken during the next ten years to address TDG (NMFS 2008a).

Pollutants

Background or ambient levels of pollutants in inflows carry cumulative loads from upstream areas in variable and generally unknown amounts. Industrial and municipal wastes from the Portland-Vancouver metro areas affect the lower river and estuary. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids including DDT, PCBs, and polyaromatic hydrocarbons (PAH) (NMFS 2001). This data also indicates that juvenile salmonids in the Columbia River estuary have contaminant body burdens in the range where sublethal effects can occur. The sources of exposure are not clear but may be widespread. Several pesticides and heavy metal contaminants have been sampled in Columbia River sediments (ODEQ 2007). In field studies, juvenile salmon from sites in the Pacific Northwest have demonstrated immunosuppression, reduced disease resistance, and reduced growth rates due to contaminant exposure during their period of estuarine residence (Arkoosh et al. 1991, 1994, 1998; Varanasi et al. 1993; Casillas et al. 1995a, 1995b, 1998a).

4.11.1.4 Physical Habitat Characteristics

Prior to extensive dam development, spring runoff brought colder, more turbid water and an array of sediments and large woody debris to the lower Columbia River. Today, much of the river's sediment and large wood is trapped in its headwater reservoirs. These characteristics affect both water quality conditions and physical channel characteristics, both of which affect habitat quality. It is known that the Columbia River estuary contained a larger island complex, more shoreline marshes, and large rafts of woody debris prior to development. In part, these habitat characteristics have been purposely altered (e.g., dredging and snag removal to facilitate navigation) and in part these changes are the result of changes in suspended sediment, turbidity, large woody debris, and stream flows associated with land and water development activities higher in the watershed. The estuary functions as an important transition environment, where smolts have the opportunity to gradually adapt to salt water, and as a nursery ground, smolts may feed and grow to sizes that may increase their chances of surviving in the ocean (Reimers 1973; Simenstad et al. 1982; Thorpe 1994). Juvenile salmon are found in the estuary all months of the year as different species, size classes, and life-history types move downstream from multiple upstream sources. Ocean-type Chinook migrants could depend entirely on the estuary for nursery habitats Healey (1982). Chum salmon, which rear in estuaries for several weeks, have been classified as the second most estuarine-dependent species.

The movements of juvenile salmon and their patterns of habitat use within estuaries are size related. Chinook and chum salmon subyearlings (fry) usually occupy shallow, nearshore habitats, including salt marshes, tidal creeks, and intertidal flats (Levy and Northcote 1982; Myers and Horton 1982; Simenstad et al. 1982; Levings et al. 1986). As subyearlings grow to fingerling and smolt stages, their distribution typically shifts toward deeper habitats farther from the shoreline (Healey 1982; Myers and Horton 1982). In the Columbia River estuary, McCabe et al. (1986) reported that subyearling Chinook in shallow intertidal habitats were smaller than subyearlings captured in deeper offshore areas. Large yearling migrants, on the other hand, may spend relatively little time in shallow-water habitat (Bottom et al. 1984). Thus, the occurrence of small subyearling salmon, including those life-history types that stay in the estuary for the longest periods, may be closely linked to the availability of certain shallow-water habitats.

Historical habitat changes may have reduced the benefit that anadromous salmonids, particularly rearing juveniles, derive from the estuary. The estuarine food webs that support these fish are apparently detritus-based, and in the Columbia estuary, the detritus-based food web has diminished in response to development. Macrodetritus derived from emergent marsh vegetation has undergone a dramatic reduction due to the loss of shallow water habitat. The loss of those production areas reduced emergent plant production by approximately 82%. Prior to development, the biomass of organisms that feed on the macrodetritus would have been 12 times the current biomass. Since those organisms are prominent prey of juvenile salmonids, it is reasonable to assume that a reduction in the food web supported by macrodetritus has had a negative effect on the anadromous salmonids (ISG 1996).

In summary, historical changes in peripheral wetland habitats, shape of the river's bottom, and flows of the Columbia River estuary have altered basic estuarine processes and conditions such as sediment transport, detrital input, and the trophic pathways that support salmon. Such changes also have affected the availability of shallow water, off-channel rearing areas that may be particularly important to small subyearling salmon with estuarine-rearing life histories. However, the specifics of salmonid ecology in the Columbia River estuary are poorly understood. Much of what is assumed about the estuarine requirements of Columbia River salmon is derived from research in much smaller Northwest estuaries, where ecological processes differ substantially from this large river-dominated system. Furthermore, available estimates of estuarine habitat change are restricted to the lower estuary below Puget Island (Thomas 1983) and exclude the tidal floodplain upriver to Bonneville Dam, which has also been extensively modified. Efforts to quantify habitat change or assess the benefits of estuary restoration to Columbia River salmon are limited by the lack of baseline information about modern and historical spatial distributions of habitats and food-web linkages.

Recent projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor and of rearing habitat for ocean-type Chinook and chum salmon. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat and will implement 44 more in just the first three years of executing the FCRPS RPA (NMFS 2008). These actions, and others that will be implemented under the FCRPS RPA, will protect and restore riparian areas, protect remaining high quality off-channel habitat, breach or lower dikes and levees to improve access to off-channel habitat, and reduce noxious weeds.

Habitat conditions in the estuary are therefore expected to improve as a result of the next 10 years of effort.

4.11.2 Hatchery Effects

Information and analysis on the effects of past and ongoing hatchery factors on the current status of ESA protected salmon and steelhead of the Columbia Basin is provided in NMFS 2004, NMFS 2006, and in NMFS 2007 (NMFS 2004b; NMFS 2006a; NMFS 2008a).

The history or evolution of hatcheries is an important factor in analyzing their past and ongoing effects. The first hatcheries, beginning in the late 19th century, provided additional fish for harvest purposes on top of large relatively healthy salmon and steelhead populations. As development of the Columbia Basin proceeded (e.g., construction of the FCRPS between 1939 and 1975), the role of hatcheries shifted to replacing losses in fish production attributable to habitat degradation and reduced salmon and steelhead survival. National Fish Hatcheries in the upper Columbia for example produce salmon and steelhead for areas blocked by federal dams (approximately 50% of the production area for upper Columbia Chinook salmon and steelhead was blocked and remains inaccessible) while federally funded hatchery programs in the Snake River are expected to replace losses of fall Chinook salmon from inundation of their spawning habitat and from reduced survival during their migration to and from the ocean because of the four Lower Snake River federal projects. The scope and level of hatchery production increased greatly during this period as impacts from development and the requirement for mitigation increased. A new role for hatcheries emerged during the 1980s and 1990s after populations declined to unprecedented low levels. Because tools were needed to help conserve salmon and steelhead resources, some hatchery programs changed their goals and practices and whole new programs were implemented including substantial new research to assess the efficacy of artificial propagation as a tool to promote conservation. Today, because nearly 90% of the Chinook salmon and steelhead habitat originally available in the Columbia Basin has been lost or degraded (Brannon et al. 2002), fish produced by hatcheries comprise the vast majority of the annual returns to the basin (CBFWA 1990). There would be few if any fish returning to many areas of the Columbia Basin and little or no tribal, public or commercial fishing opportunity without hatcheries.

Hatchery programs are mitigation for factors limiting salmon and steelhead survival. The nearly two hundred programs that operate in the Columbia Basin are mitigation for Federal and public and private utilities projects. NMFS 2004 evaluates hatchery effects at two levels: at the population level and at the ESU or DPS level. For programs in the Interior Columbia (upstream from Bonneville Dam), NMFS 2006 developed with input provided by members of the Hatchery and Harvest Workgroup of the FCRPS collaboration; (1) summarized the major factors limiting salmon and steelhead recovery at the population scale, (2) provided an inventory of existing hatchery programs including their funding source(s) and the status of their regulatory compliance under the ESA and under the National Environmental Policy Act (NEPA), (3) summarized the effects on salmon and steelhead viability from current hatchery operations, and (4) identified new opportunities or changes in hatchery programs likely to benefit population viability. As a follow-up to this report, NMFS developed guidance for determining hatchery effects, including a general assessment of hatchery programs in the upper Columbia and Snake River Basin, and presented this paper and results to the Hatchery and Harvest Workgroup and to the Policy Workgroup in August of 2006. NMFS received comments and made edits to this paper to provide updated guidance.

During the last one hundred or more years, artificial propagation has become an integral and necessary component in the management and conservation of salmon and steelhead and genetic resources that represent the ecological and genetic diversity of a species (these can reside in fish spawned in a hatchery as well as in fish spawned in the wild) (Hard et al. 1992; NMFS 2005c). Hatchery programs can preserve the raw materials (i.e., genetic resources) that ESU and DPS conservation depends on and buy time until the factors limiting salmon and steelhead viability are addressed. In absence of hatchery programs like this, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether. In this role, hatchery programs can reduce the risk of extirpation, and thereby mitigate the immediacy of an ESU's extinction risk (NMFS 2005c). In absence of hatchery programs like this, genetic resources important to ESU or steelhead DPS survival and recovery would disappear at an accelerated rate or be lost altogether. Hatchery programs that only conserve genetic resources however "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or long-term (NMFS 2005d). Accordingly, "Hatcheries are not a proven technology for achieving sustained increases in adult production" (NRC 1995), and the long-term effects of hatchery supplementation remain untested (Araki et al. 2007a).

Captive-broodstock and safety-net programs, including some hatchery supplementation programs, function to preserve genetic resources. In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish (i.e., F1 hatchery-origin fish) but increased NOF viability cannot be attributed to the program. For example, hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival, or when access to spawning and rearing habitat is blocked. "The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery" (HSRG 2004). Under circumstances like these and in the short-term, the demographic risks of extinction exceed genetic and ecological risks to NOF from hatchery supplementation. Benefits like this should be considered *transitory* or short-term and do not contribute to survival rate changes necessary to meet ICTRT abundance and productivity viability criteria (ICTRT 2007).

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. For example, in Puget Sound, eight Chinook salmon hatchery programs are specifically implemented to preserve native populations in their natal watersheds "where habitat needed to sustain the populations naturally at viable levels has been lost or degraded" (NMFS 2005d). These hatchery programs deserve credit for helping "to preserve remaining genetic diversity, and likely have prevented the loss of several populations" (NMFS 2005d). Until, however, the factors limiting salmon and steelhead productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon and steelhead viability may not be realized.

In general, there are two options for hatchery programs to increase viability. They can reduce or eliminate hatchery impacts that reduce NOF survival, and second, they can be affirmatively used as a conservation tool to benefit recovery. In both cases, a net increase in viability (i.e., NOF abundance, productivity, spatial distribution, and diversity) is partially or wholly attributable to hatchery actions. For example, steps to control hatchery fish straying or to ensure that adult and juvenile fish passage is not impeded by hatchery facilities are actions that qualify under this category (i.e., they reduce hatchery impacts). Helping fish to re-colonize their former range and become self-sustaining using hatchery–origin fish also would qualify for credit.

Under the RPA (Action 39) in the 2008 FCRPS Biological Opinion, the Action Agencies will continue funding hatcheries as well as adopt programmatic criteria for funding decisions on hatchery mitigation programs for the FCRPS that incorporate BMPs. NMFS will consult on the operation of existing or new programs when Hatchery and Genetic Management Plans (HGMPs) are updated by hatchery operators with the Action Agencies as cooperating agencies. For the lower Columbia, new HGMPs must be submitted to NMFS and ESA consultations initiated by July 2009 and consultations must be completed by January 2010. Subject to subsequent hatchery specific ESA § 7(a)(2) consultation, implementation of BMPs in NMFS-approved HGMPs are expected to: 1) integrate hatchery mitigation and conservation objectives, 2) preserve genetic resources, and 3) accelerate trends toward recovery as limiting factors and threats are addressed and natural productivity increases. These benefits, however, are not relied upon for this consultation pending completion of the future consultations.

4.11.3 Fisheries

For thousands of years, Native Americans have fished for salmon and steelhead, as well as other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls; to spears, weirs, and traps (usually in smaller streams and headwater areas). Commercial fishing developed rapidly with the arrival of European settlers and the advent of canning technologies in the late 1800s. The development of non-Indian fisheries began circa 1830, and by 1861 commercial fishing was an important economic activity. The four Columbia River “Stevens” Treaty Tribes (the Nez Perce, Umatilla, and Warm Springs Tribes, and the Yakama Indian Nation) entered into treaties with the United States in 1855. In exchange for the Indians relinquishing their interest in certain lands, the treaties reserved to the Tribes "exclusive" on-reservation rights and the right to take "fish at all usual and accustomed places in common with citizens of the United States" outside the reservations on the Columbia River and major tributaries.

Treaty Indian fishing rights in the Columbia Basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon,* No. 68-513 (D. Oregon, continuing jurisdiction case filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of the Interior (U.S. Fish and Wildlife Service and Bureau of Indian Affairs) and Department of Commerce (NOAA), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho.

In *U.S. v. Oregon*, the court affirmed that the treaties reserved for the Tribes’ 50% of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas. In at least a half-dozen published opinions and several unpublished opinions in *U.S. v. Oregon*, as well as dozens of rulings in the parallel case in *U.S. v. Washington* (interpreting the same treaty language for Tribes in the Puget Sound area), the courts have established a large body of case law setting forth the fundamental principles of treaty rights and the permissible limits of conservation regulation of treaty fisheries.

Table 4.11-5 displays the most recent modification to the *U.S. v. Oregon* agreement as of May 2008. As displayed below, the 2008-2017 Management Agreement concluded that the harvest elements of the Management Agreement for upriver Chinook, sockeye, steelhead, coho and white sturgeon remain in effect through December 2017. As has been the case with prior agreements, the current agreement is subject to ESA Section 7 consultation by NMFS that was completed in May 2008 (NMFS 2008c).

4.11.4 Status of Designated Critical Habitat in the Lower Columbia River and Estuary

The critical habitat that NMFS designated for each of 12 species of salmon and steelhead includes the lower Columbia River below the confluence of the Willamette and the estuary. These areas are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats to avoid predators, compete successfully for forage organisms, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide resources needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.[2]

Factors that have limited the functioning and conservation value of PCEs in the estuary are:

- Changes in the estuary that have increased the number of avian predators *[Caspian terns and double-crested cormorants]*
- Diking and reduced peak spring flows have eliminated much of the shallow water, low velocity habitat *[agriculture and other development in riparian areas; FCRPS and Upper Snake water management]*

The FCRPS Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these PCEs and will continue to take actions under the RPA in the 2008 FCRPS Biological Opinion. For example, the safe passage of juvenile salmonids improved beginning in 1999 when Caspian terns were relocated from Rice to East Sand Island, and relocation of terns to sites outside the Columbia basin will be completed by 2010. The double-crested cormorant colony, which has grown during that period, will be addressed by a management plan. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the tidally influenced zone of the estuary (between Bonneville Dam and approximately RM 40) have improved the functioning of the juvenile migration corridor. The FCRPS Action Agencies recently implemented 18 estuary habitat projects that removed passage barriers, providing access to good quality habitat and will implement 44 more in just the first three years of executing the FCRPS RPA (NMFS 2008a). These actions, and others that will be implemented under the FCRPS RPA, will protect and restore riparian areas, protect remaining high quality off-channel habitat, breach or lower dikes and levees to improve access to off-channel habitat, and reduce noxious weeds. The PCEs safe passage, water quality, cover/shelter, and forage will be enhanced. Projects that improve estuarine habitat will have long-term beneficial effects at the project scale. Adverse effects to PCEs during construction are expected to be minor, occur only at the project scale, and persist

[2] Habitat requirements and adult use of the estuary are unknown (Fresh et al. 2005).

for a short-time (no more than a few weeks and typically less). The positive effects on the functioning of PCEs and the conservation value of critical habitat will be long-term.

Table 4.11-5 Expected incidental take of listed salmonids for non-Treaty and treaty Indian Fisheries under the 2008 U.S. v Oregon Agreement expressed in terms of harvest rates unless otherwise indicated.

ESUs	Total Expected Take (%)	Treaty Indian (%)	Non-Indian (%)
Snake River Fall Chinook Salmon	17.9-32.2 [1]	11.6-23.0[1]	5.9-9.0[1]
Snake River Spring/Summer Chinook Salmon	7.0 - 14.6[2]	5.8-12.5[2]	1.2-2.1[2]
Lower Columbia River Chinook Salmon			
Spring Component	0.2-2.0	0	0.2-2.0
Tule Component (LRH[13] stock)	7.7-14.9[3]	0	7.7-14.9[3]
Bright Component (LRW[14] stock)	6.0-18.8 [3]	0	6.0-18.8 [3]
Upper Willamette River Spring Chinook Salmon	5.0-11.0[4]	0	5.0-11.0[4]
Snake River Basin Steelhead			
A-Run Component	na[5]	4.1-12.4[6]	0.9-1.7
B-Run Component	14-21.8[7]	13-20[7]	1.0-1.8[7]
Lower Columbia River Steelhead			
Winter component	na[5]	<1.4-6.9[8,9]	0.2-1.0 [3]
Summer component	na[5]	<4.1-12.4[6,8]	0.2-0.4 [3]
Upper Willamette River Steelhead	na[5]	0	0.2-1.0 [3]
Middle Columbia River Steelhead			
Winter component	na[5]	1.4-6.9[9]	0.2-1.0 [3]
Summer component	na[5]	4.1-12.4[6]	0.9-1.7
Upper Columbia River Spring Chinook Salmon	7.0-14.6[2]	5.8-12.5[2]	1.2-2.1[2]
Columbia River Chum Salmon	1.6	0	1.6
Upper Columbia River Steelhead			
Natural-origin Component	na[5]	4.1-12.4[6]	0.9-1.7
Hatchery Component	na[5]	3.8-9.2[10]	7.6-11.2
Snake River Sockeye Salmon	2.8-7.1[10]	2.8-6.1[10]	0.0-1.0[10]
Lower Columbia Coho Salmon	13.3-24.3[11]	0	13.3-24.3[11]
Research, Monitoring, and Evaluation	0.1-0.5 [12]		

Notes:

- Fisheries are normally managed in season with buffers and other conservative management measures that typically result in impacts being less than allowed ESA limits.
- Allowed take for spring Chinook, fall Chinook, B-steelhead, sockeye, and coho varies by run size.
- Ranges represent recent year averages.
- Steelhead harvest rates assume equal harvest rates on any DPS present in fishery.

Footnotes:

1. Range based on 1999-2007 average under fixed harvest rate schedule. Expected impacts may increase under new abundance based management.
2. Range based on 2001-2007 average for treaty and non-treaty fisheries. Treaty spring Chinook harvest impacts on listed fish can be higher than river mouth run size harvest rates, because of changing hatchery/wild proportions between the river mouth and Bonneville Dam. Future expected impacts may be higher if run sizes indicate use of upper end of harvest rate schedule.
3. Range based on 2003-2007 harvest rates for in-river fisheries.
4. Range of harvest rate for Columbia River mainstem fisheries only.
5. Steelhead impacts are not additive, because of different methods of calculating harvest rates.
6. Range based on 1998-2007 treaty mainstem harvest rates. Tributary impacts not included.
7. Range based on 1998-2007 fisheries.
8. Range based on 1998-2007 treaty mainstem harvest rates. Tributary impacts not included.
9. Expected impact for above Bonneville portion of ESU only. Impacts on entire ESU will be lower winter season harvest rates are based on catch in Bonneville Pool divided by Bonneville Dam count of winter steelhead. Tributary impacts not included.
10. Range based on 1998-2007 fisheries.
11. Range based on 2003-2007 fisheries.
12. Includes research, monitoring and evaluation that is currently in place. For Chinook and coho ESU's, the range is 0.1-0.5% for each ESU. For steelhead DPS' and sockeye and chum ESU's the range is 0.1-0.3% for each DPS.
13. Lower Columbia River hatchery origin (LRH)
14. Lower Columbia River non-hatchery origin (LRW)

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Chapter 5.0
Effects of the Proposed Action

Section 5.1
Effects of the Proposed Action Common to Multiple Areas

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5 EFFECTS OF THE PROPOSED ACTION

Effects of the Proposed Action are defined as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will be added to the environmental baseline" (50 CFR 402.02). When project operations directly or immediately injure or kill fish or damage habitat at or near the project site, those are considered direct effects of the project. Indirect effects are defined in 50 CFR 402.02 as "those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur." They include the effects on listed species of future activities that are induced by the PA and that occur after the action is completed. "Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration" (50 CFR 402.02).

NMFS conducted two related analyses, one to inform its jeopardy determination, and one to inform its critical habitat determination. For the jeopardy analysis, NMFS determined whether the PA is likely to reduce the abundance, productivity, or distribution of a listed ESU. Because there is a paucity of detailed data for some Chinook and steelhead populations, some of this determination is qualitative in nature.

For the critical habitat analysis, NMFS evaluated the effect of the PA on the primary constituent elements (PCEs) of critical habitat and, in particular, on the essential features of that critical habitat by comparing the conditions of the habitat with and without the PA.

5.1 EFFECTS OF THE PROPOSED ACTION COMMON TO MULTIPLE AREAS

NMFS' analysis of the effects of the PA for each occupied tributary and the mainstem Willamette River, the lower Columbia River and the Columbia River plume, is presented in subsections 5.2 through 5.11. This subsection 5.1 describes the effects of specific parts of the Proposed Action that are generally applicable to the tributaries and fish species.

Except as identified below, conditions under the environmental baseline (Chapter 4) are assumed to continue during the life of this consultation.

The Proposed Action includes a number of measures that would have few, if any, direct effects on listed anadromous fish. These measures include, but are not limited to the following:

- WATER committee process and structure
- Willamette System Review Study

The Proposed Action also includes activities that have similar effects throughout the action area. These measures include:

- RME studies
- Revetments

- Hatchery program

NMFS describes effects of these actions in the following subsections.

5.1.1 WATER Committee Process and Structure

Because, the Willamette River is the largest and most densely populated tributary in the Columbia River Basin, effective protection and recovery of ESA listed species in the Willamette Basin's diverse and complex array of streams, habitat, and anthropogenic features will require an ecosystem-wide perspective and the cooperative, interrelated efforts of all concerned parties with resource management authority and responsibility. The structure of the WATER committees and their employment of a collaborative and adaptive planning and review process is designed and intended to serve the Action Agencies and the Services in addressing these needs. Informed decision making will require consideration of the feasibility, effectiveness, and associated risks of actions to be taken, including their integration with or impacts upon actions planned or being taken by others within the Willamette Basin.

While the necessity of a collaborative effort in achieving effective protection and recovery of ESA listed species in the Willamette Basin is apparent, the responsibility for carrying out the measures included in the Action Agencies' Proposed Action remains the sole responsibility of the Action Agencies. Likewise, the authority for assessing the adequacy of individual measures or combinations of measures in avoiding jeopardy to listed species or adverse modification of critical habitat and in effectively achieving protection and recovery goals remains solely the responsibility of the Services.

NMFS does not believe these essential responsibilities are clearly described in the Proposed Action. In order to ensure that decisions are carried out consistent with this Opinion, the Action Agencies must ensure that the Charter for WATER and its technical coordinating committees describes a decision-making process that recognizes the unique role played by NMFS and USFWS in decisions related to measures covered in their respective Biological Opinions.

5.1.2 Willamette System Review Study

The Action Agencies propose to undertake a comprehensive assessment of the Willamette Basin (USACE 2007a) to comprehensively evaluate the feasibility and relative benefits of structural and related operational modifications designed to improve survival and productivity of ESA-listed aquatic species at Willamette dams. The effect of the Willamette Project on the Willamette Basin is widespread, so the research area will also be large. Thus, the areas of investigation would include, but are not limited to:

- Upstream and downstream passage feasibility at USACE facilities
- Monitoring of basin metrics at USACE and non-USACE facilities
- Hatcheries, hatchery traps, and hatchery barriers
- Temperature control systems at dams
- Habitat Restoration
- Water Quality Improvements

NMFS discusses effects of the Willamette System Review Study in each of the subbasin effects sections where Project dams and operations would be evaluated (5.2 Middle Fork Willamette, 5.3 McKenzie, 5.5 South Santiam, and 5.6 North Santiam). In general, the study would help provide information regarding the feasibility and relative benefits of various mitigation measures, but would also have some adverse effects. As described below in 5.1.3, fish would be used in field studies and some individuals would be stressed, injured, and killed from these studies. Additionally, until the studies are completed, none of the major improvements to fish passage, temperature control, and other facilities will be carried out, exposing fish to degraded conditions below the dams and limited access to upstream habitat for an unknown number of years.

5.1.3 RME Studies

RME studies under the Proposed Action would have direct effects on both UWR Chinook and UWR steelhead that are used in field studies. Fish may be trapped, examined, released, confined, re-located, marked or tagged and subjected to related handling operations, subjected to the administration of pharmacological agents, including anesthetics, subjected to capture by electrofishing, propagated, transported between stream basins, killed or injured during test and control conditions, and affected in diverse other ways.

5.1.3.1 Effect on Species Status

Under the Proposed Action, numerous fish protection measures will be carried out that depend on site-specific evaluations to identify feasible alternatives. These measures include restoration actions to address, in part, habitat factors limiting the viability of salmonid populations. These altered habitat conditions will affect the distribution and abundance of Chinook and steelhead.

RM&E actions are a necessary tool for providing data critical to adaptive management. This monitoring information will allow adaptive management decisions to be made to ensure the long-term persistence of listed fish species in the Willamette Basin, as well as the ability to respond to significant changes in environmental conditions. Its implementation will also ensure that managers have information to determine the effectiveness of the Proposed Action.

Under the RME Proposed Action #2.14, Chapter 2, the Action Agencies will monitor and evaluate the effectiveness of various aquatic measures in the Proposed Action, including fish passage, water quality, habitat quality and quantity, and hatchery supplementation programs. The Action Agencies will prepare annual monitoring reports that describe the work conducted each year and the results of each study. Work will be conducted by the Action Agencies, or those hired by the Action Agencies to conduct the work (their contractors).

The various monitoring and evaluation activities for anadromous fish measures would cause many types of take (as defined by ESA §3(19) - The term ‘‘take’’ means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct). The first part of this Section is devoted to a discussion of the general effects known to be caused by the general potential proposed activities—regardless of where they occur or what species are involved.

Research and monitoring programs identified in the RPA will be funded or conducted, or both, by the Action Agencies. These programs are expected to take listed UWR Chinook salmon and steelhead. The activities include, but are not limited to, the following: (1) evaluating fish passage through reservoirs and various outlets at dams; (2) evaluating alternative fish passage facilities, screens, and other bypass systems; (3) evaluating effects of alternative flow scenarios, flow pulses, minimum and maximum flow levels, and of various ramping rates; (4) evaluating salmonid production (i.e., smolt-to-adult survival rates, for example); (5) determining stock composition, population trends, and life history patterns; (6) evaluating habitat restoration projects; (7) evaluating effects of artificial production and supplementation on natural-origin listed fish; (8) evaluating alternative methods for achieving temperature control on fish and fish habitat below Project dams; (9) investigating migration timing and migratory patterns; (10) moving fish above artificial barriers to migration; (11) investigating fish behaviors in streams, reservoirs and off-channel areas; (12) evaluating fish spawning below dams; (13) monitoring and mitigating the effects of USACE dams; (14) evaluating effects of water diversions on fish; (14) conducting total dissolved gas experiments; (15) and investigating effects of alternative reservoir levels on fish passage and survival.

The following subsections describe the types of activities that NMFS expects the Action Agencies will use to carry out the research and monitoring requirements of the Proposed Action. The types of activities are organized into the following categories: observation, capture/handle/release, tagging/marking, biological sampling, and sacrifice. Each is described in terms broad enough to apply to every relevant plan informed by previous experience. The activities would be carried out by trained professionals using established protocols and have widely recognized specific impacts. The Action Agencies are required to incorporate NMFS' uniform, pre-established set of minimization measures, including training, protocol standardization, data management, and reporting for these activities (e.g. electrofishing). These measures will be included in the specific monitoring plans subject to NMFS' approval.

5.1.3.2 Observation

For some studies, fish will be observed in-water (i.e., snorkel surveys). Direct observation is the least disruptive and simplest method for determining presence/absence of the species and estimating their relative abundance. Its effects are also generally the shortest-lived among any of the research activities discussed in this Chapter. Typically, a cautious observer can obtain data without disrupting the normal behavior of a fish. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge behind rocks, vegetation, and deep water areas. In extreme cases, some individuals may temporarily leave a particular pool or habitat type when observers are in their area. Researchers minimize the amount of disturbance by slowly moving through streams, thus allowing ample time for fish to reach escape cover; though it should be noted that the research may at times involve observing adult fish—which are more sensitive to disturbance. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all they can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

Monitoring of population status and the effects of programs and actions will include conducting redd surveys to visually inspect and count the nests or redds of spawning salmon and steelhead. Harassment is the primary form of take associated with these observation activities, and few if any injuries or deaths are expected to occur—particularly in cases where the observation is to be conducted solely by researchers on the stream banks or from a raft rather than walking in the water. Fish may temporarily move off of a redd and seek cover nearby until the observer has past. There is little a researcher can do to mitigate the effects associated with observation activities because those effects are so minimal. In general, all researchers can do is move with care and attempt to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves.

5.1.3.3 Capture/Handle/Release

Capturing and handling fish causes them stress—though they typically recover fairly rapidly from the process and therefore the overall effects of the procedure are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and the point where fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18 degrees C or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not regularly emptied. Debris buildup at traps can also kill or injure fish if the traps are not monitored and regularly cleared of debris.

The use of capture/handling/release protocols, which are generally standardized throughout the Columbia basin and include maintaining high quality water (appropriate temperature, oxygen levels, anesthetic concentrations) and keeping fish in water to the maximum extent possible, serve to minimize potential adverse impacts on individual fish. Based on experience with the standard protocols that would be used to conduct the research and monitoring, no more than five percent and in most cases, less than two percent of the juvenile salmonids encountered are likely to be killed as an unintentional result of being captured and handled. In any case, researchers will employ the standard protocols and thereby keep adverse effects to a minimum. Finally, any fish unintentionally killed by the research activities in the proposed permit may be retained as reference specimens or used for other research purposes.

5.1.3.4 Smolt, rotary screw (and other out-migration) traps

Smolt, rotary screw (and other out-migration) traps, are generally operated to gain population specific information on natural population abundance and productivity. On average, they achieve a sample efficiency of 4 to 20% of the emigrating population from a river or stream, depending on the river size, although under some conditions traps may achieve a higher efficiency for a relatively short period of time (NMFS 2003d). Based on experience in Columbia River tributaries the mortality of fish captured/handled/released at rotary screw type juvenile fish traps would be expected to be two percent or less on target species.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 °F (18 °C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank. The potential for unexpected injuries or mortalities to ESA-listed fish will be reduced in a number of ways.

Study protocols and ITS terms and conditions define how the potential for stress will be minimized. The action specifies that the trap would be checked and fish handled in the morning. This would ensure that the water temperature is at its daily minimum when fish are handled. Fish may not be handled if the water temperature exceeds 69.8 °F (21 °C). Sanctuary nets must be used when transferring fish to holding containers to avoid potential injuries. The investigator's hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas.

5.1.3.5 Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simple harassment to actually killing the fish. The amount of unintentional mortality attributed to electrofishing may vary widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. Electrofishing can have severe effects on adult salmonids. Spinal injuries in adult salmonids from forced muscle contraction have been documented. Sharber and Carothers (1988) reported that electrofishing killed 50% of the adult rainbow trout in their study. The long-term effects electrofishing has on both juveniles and adult salmonids are not well understood, but long-term experience with electrofishing indicates that most impacts occur at the time of sampling and are of relatively short duration.

The effects electrofishing may have on the threatened species would be limited to the direct and indirect effects of exposure to an electric field, capture by netting, holding captured fish in aerated tanks, and the effects of handling associated with transferring the fish back to the river (see the previous subsection for more detail on capturing and handling effects). Most of the studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish (Sharber and Carothers 1988) and may therefore be subject to lower injury rates (Hollender and Carline 1994; Dalbey et al. 1996; Thompson et al. 1997). McMichael et al. (1998) found a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin. The incidence and severity of electrofishing damage is partly related to the type of equipment used and the waveform produced (Sharber and Carothers 1988; McMichael 1993; Dalbey et al. 1996; Dwyer and White 1997). Continuous direct current (DC) or low-frequency (30 Hz) pulsed DC have been recommended for electrofishing (Snyder 1995; Dalbey et al. 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (McMichael 1993; Sharber et al. 1994; Dalbey et al. 1996). Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey et al. 1996; Ainslie et al. 1998). These studies indicate that although some of the

fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes they show no growth at all (Dalbey et al. 1996).
NMFS' electrofishing guidelines (2000c) will be followed in all surveys using this procedure. The guidelines require that field crews be trained in observing animals for signs of stress and shown how to adjust electrofishing equipment to minimize that stress. Electrofishing is used only when all other survey methods are not feasible. All areas for stream and special needs surveys are visually searched for fish before electrofishing may begin. Electrofishing is not done in the vicinity of redds or spawning adults. All electrofishing equipment operators are trained by qualified personnel to be familiar with equipment handling, settings, maintenance, and safety. Operators work in pairs to increase both the number of fish that may be seen and the ability to identify individual fish without having to net them. Working in pairs also allows the operators to net fish before they are subjected to higher electrical fields. Only DC units will be used, and the equipment will be regularly maintained to ensure proper operating condition. Voltage, pulse width, and rate will be kept at minimal levels and water conductivity will be tested at the start of every electrofishing session so those minimal levels can be determined. Due to the low settings used, shocked fish normally revive instantaneously. Fish needing to be revived will receive immediate, adequate care.

The preceding discussion focused on the effects of using a backpack unit for electrofishing and the ways those effects will be mitigated. It should be noted, however, that in larger streams and rivers electrofishing units are sometimes mounted on boats. These units often use more current than backpack electrofishing equipment because they need to cover larger (and deeper) areas, and as a result, can have a greater impact on fish. In addition, the environmental conditions in larger, more turbid streams can limit the operators' ability to minimize impacts on fish. For example, in areas of lower visibility it is difficult for operators to detect the presence of adults and thereby take steps to avoid them. Because of its greater potential to harm fish, and because NMFS has not published appropriate guidelines, boat electrofishing has not been given a general authorization and all boat electrofishing projects will be evaluated on a case by case basis.

5.1.3.6 Angling

Fish that are caught and released alive as part of an RM&E project may still die as a result of injuries or stress resulting from the capture method or handling. The likelihood of mortality varies widely, based on a number of factors including the gear type used, the species, the water conditions, and the care with which the fish is released. As detail for the effects analysis below, general catch-and-release effects for steelhead and Chinook salmon are discussed here.

Catch and Release mortality –The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality is low. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catch and release of adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Data on summer-run steelhead and warmer water conditions are less abundant (Cramer et al. 1997). Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Hooton (1987) because of warmer water and extended freshwater residence of summer fish which make them more likely to be caught. As a result, NMFS expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of natural or synthetic bait will reduce juvenile steelhead mortality more than any other angling regulatory change. Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984) mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found little difference (or inconclusive results) in the mortality of juvenile steelhead associated with using barbed versus barbless hooks, single versus treble hooks, and different hook sizes (Schill and Scarpella 1995; Taylor and White 1992; Mongillo 1984). However, some investigators believe that the use of barbless hooks reduces handling time and stress on hooked fish and adds to survival after release (Wydoski 1977). In summary, catch-and-release mortality of juvenile steelhead is expected to be less than 10% and approaches 0% when researchers are restricted to use of artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for natural-origin spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay et al. 2004). In hooking mortality studies, hooking location and gear type is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). A large portion of the mortality in the Lindsay et al. (2004) study was related to deep hooking by anglers using prawns or sand shrimp for bait on two-hook terminal tackle. Other baits and lures produced higher rates of jaw hooking than shrimp, and therefore produced lower hooking mortality estimates. The Alaska study reported very low incidence of deep hooking by anglers using lures and bait while fishing for salmon.

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee (TAC 2008) has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (NMFS 2005c). For similar reasons, NMFS currently applies the 10% rate to provide conservative estimates of the hook and release mortality when evaluating the impact of proposed RM&E activities using angling as a monitoring technique.

5.1.3.7 Tagging & Marking

Techniques such as passive integrated transponder tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

5.1.3.7.1 Passive Integrated Transponder (PIT) tag

A passive integrated transponder (PIT) tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al. 1987; Jenkins and Smith 1990; Prentice et al. 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically-or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Connor et al. 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

5.1.3.7.2 Coded wire tags (CWTs)

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon. However, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

5.3.1.7.3 Radio tagging

Radio tagging is another method for tagging fish. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting radio tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

5.3.1.7.4 Fin clipping

Fin clipping is the process of removing part or all of one or more fins to alter a fish's appearance and thus make it identifiable. When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, or severing individual fin rays (Kohlhorst 1979; Welch and Mills 1981). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it. Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 % recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are removed. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality but other studies have been less conclusive.

Regardless, any time researchers clip or remove fins, it is necessary that the fish be handled. Therefore, the same safe and sanitary conditions required for tagging operations also apply to clipping activities.

5.1.3.8 Stomach Flushing

Stomach flushing is a technique to induce fish to regurgitate the contents of their stomachs without killing the fish. Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light et al. (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100% for the entire observation period. In contrast, Meehan and Miller (1978) determined the survival rate of electrofished, anesthetized, and stomach flushed natural-origin and hatchery coho salmon over a 30-day period to be 87% and 84% respectively.

5.1.3.9 Biological Sampling

5.1.3.9.1 Genetic Samples (fin clips)

Genetic sampling uses non-lethal methods to obtain material that is used to assess parentage and develop population structure.

5.1.3.9.2 Sacrifice

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if juveniles are forever removed from the listed species' gene pool; if the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed, but so are all their potential progeny. Thus, killing pre-spawning adults has the greatest potential to affect the listed species. Due to this, NMFS rarely allows it to happen. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults.

5.1.3.10 Habitat surveys & installation of monitoring devices

The following potential effects to listed species and their habitats associated with the proposed actions for stream channel, floodplain, and upland surveys and installation of stream monitoring devices - erosion and sedimentation, compaction and disturbance of streambed sediments - are negligible and would have little impact on compaction or instream turbidity. The effect of stream channel, floodplain, and upland surveys and installation of stream monitoring devices activity is described in the HIP Biological Opinion (2.2.1.2.1 Stream Channel, Floodplain, and Uplands Surveys and Installation Stream Monitoring Devices such as Streamflow and Temperature Monitors) (NMFS 2008d) as applicable. These actions will incorporate the conservation measures for general construction identified in that Biological Opinion. Similarly, there is the potential for trampling a negligible amount of vegetation during upland and floodplain surveys, but the vegetation would be expected to recover.

Excavated material from cultural resource testing conducted near streams may contribute sediment to streams and increase turbidity. The amount of soil disturbed would be negligible and would have a minimal effect on instream turbidity.

5.1.3.11 Benefits of Monitoring & Evaluation

NMFS will not agree with a monitoring plan if it operates to the disadvantage of an ESA-listed anadromous fish species that is the subject of the plan. In addition, NMFS does not support

monitoring plans unless the proposed activities are likely to result in a net benefit to the listed species, and benefits accrue from the acquisition of scientific information.
For more than a decade, research and monitoring activities conducted with anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information on anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, PIT-tagging efforts have increased the knowledge of anadromous fish migration timing and survival, and fish passage studies have provided an enhanced understanding of fish behavior and survival when moving past dams and through reservoirs. By approving plans, NMFS will enable information to be acquired that will enhance resource manager's ability to make more effective and responsible decisions to sustain anadromous salmonid populations that are at risk of extinction, to mitigate impacts to endangered and threatened salmon and steelhead, and to implement recovery efforts. The resulting data continue to improve the knowledge of the respective species' life history, specific biological requirements, genetic make-up, migration timing, responses to anthropogenic impacts, and survival in the river system.

RME studies comprise an essential part of the Proposed Action. In multiple instances, detailed information on geographically-specific environmental conditions (e.g., quantity and distribution of functional spawning and rearing habitat) and the extent to which ongoing Willamette Project operations are continuing to affect those conditions (e.g., flow variation and duration in relation to sediment transport dynamics, channel and habitat complexity, and related juvenile fish behavior and survival) is lacking. In other cases, known problems attributable to Willamette Project dams and operations (e.g., migration barriers and water temperature alteration) cannot be addressed by the Action Agencies until they have narrowed uncertainties about the most prudent and effective remedies. Consequently, the ability of the Action Agencies to carry out meaningful conservation measures within the period covered by this Biological Opinion will often depend upon their ability to complete studies and make timely, informed decisions on how best to achieve protection and restoration objectives associated with each of the listed species.

NMFS will need to make sure that studies the Action Agencies have proposed to assure good decision-making, or to document timely progress toward achieving protection and restoration objectives, are designed and conducted in a manner that is in keeping with the original intent of the RPA measures. NMFS must also assure that the results of these studies are applied effectively and in a timely manner.

5.1.4 Revetments

As described in Chapter 2, Proposed Action, the USACE was authorized to construct and maintain bank protection structures (generally termed revetments) along the mainstem Willamette River and its tributaries. The purpose of these structures is to protect farmland, roads, bridges, and other developments from bank erosion and flooding. The USACE is responsible for maintenance of revetments constructed through 1950, and non-federal sponsors are responsible for those constructed after 1950. Despite the USACE's ongoing maintenance responsibility at some sites, the USACE is not authorized to remove or modify existing revetments without first obtaining landowner approval and a non-federal sponsor.

The USACE constructed about 100 miles of revetments along the mainstem Willamette River and its tributaries, and has entered into agreements to maintain approximately 42 miles of these structures into the future (USACE 2000). These structures limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent small, unfavorable temperature increases) and contribute LWD.

The Proposed Action requires the USACE to continue to maintain about 42 miles of revetments. It also includes an evaluation of the effects of these structures and possible identification of opportunities to offset or ameliorate their effects to a degree and on a schedule yet to be defined. However, the Proposed Action includes no firm commitment to remove any of these structures, or to restore habitat as part of the continued existence and maintenance of these revetments. Thus, the effect of the Proposed Action across all of the areas affected within the Willamette Basin would be to continue to diminish habitat suitability for multiple life stages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support larger and more productive salmonid populations. These adverse effects are described within each of the Effects Chapters (5.2 through 5.10) for the subbasins and mainstem Willamette where the USACE proposes to continue to maintain revetments.

5.1.5 General Effects of Hatchery Programs on ESA-listed Salmon & Steelhead

The analysis of the effects of the proposed hatchery programs in the Willamette Basin are contained in three components. The first component (section 5.1.5.1) describes the long-term vision for the management of the hatchery spring Chinook, summer steelhead, and resident rainbow trout programs that has been discussed in detail among the co-managers in the Willamette over the last several years (including at Steelhead and Chinook Above Barriers (SCAB) coordination meetings with representatives from ODFW, USACE, NMFS, Forest Service, BLM, and other agencies). The second component (section 5.1.5.2) is a thorough evaluation, based on the latest scientific literature, of the general effects of hatchery programs on ESA-listed salmon and steelhead. The third component [sections 5.2.5 (Middle Fork Willamette), 5.3.5 (McKenzie), 5.4.5 (Calapooia), 5.5.5 (South Santiam), 5.6.5 (North Santiam), 5.7.5 (Molalla), 5.8.5 (Clackamas), 5.9.5 (Coast Fork and Long Tom), and 5.10.5 (mainstem Willamette River)] are specific assessments of the effects of the hatchery programs at the individual population level for the UWR Chinook ESU and winter steelhead DPS.

5.1.5.1 Vision for Hatchery Management in the Willamette Basin

The vision statement described here for the hatchery programs in the Willamette Basin was initiated by NMFS in 2004. At that time, it was unclear how the hatchery programs would be managed over the short- and long-terms, given new information on the status of the natural-origin populations since all returning hatchery fish have been marked in 2002 and the increased effort to outplant adult Chinook above the impassable dams back into their historical habitat. The draft vision statement was presented to the Willamette Steelhead and Chinook Above Barriers (SCAB) -- a multi-agency coordination group with representatives from ODFW, NMFS, USACE, BPA, Forest Service, and BLM. The vision was reviewed and discussed in the SCAB group over a period of time. The vision described in the following sections represents the latest product from the SCAB group.

The following hatchery management vision has also taken into account other important ESA scientific and planning documents, such as WLCTRT documents (Myers et al. 2006; WLCTRT and ODFW 2006; McElhany et al. 2007), Willamette River Draft Recovery Plan (ODFW 2007b), and the Hatchery Scientific Review Group (HSRG) preliminary recommendations on the review of Willamette hatchery programs. It is important to note the Willamette River Recovery Plan and HSRG recommendations are still in draft and have not been finalized. The historical population structure identified in Myers et al. (2006) formed the basis of the populations identified in this hatchery management vision statement. The latest viability criteria (WLCTRT and ODFW 2006) and current viability status evaluations (McElhany et al. 2007) were used to help guide hatchery actions needed in the short-term to help improve the status of the high risk populations, and to help establish the long-term actions necessary to obtain a viable ESU and DPS comprised predominately of natural-origin populations with minimal hatchery influence. The draft Willamette River Recovery Plan identified strategies and actions for management of hatchery programs and reintroducing fish back into their historical habitat above Willamette Project dams. The hatchery vision is consistent with the draft Recovery Plan strategies and actions. The HSRG recently conducted a review of Willamette hatchery programs as part of their Columbia Basin Hatchery Review process. The preliminary HSRG recommendations from the review of Willamette hatchery programs did not identify any issues that were contrary to the hatchery vision statement presented here.

5.1.5.1.1 Spring Chinook Hatchery Programs

Background

The existing hatchery Chinook broodstocks were originally founded from their respective local populations when the Willamette Project dams were built. Fisheries managers and the USACE agreed at that time to use hatchery mitigation to help offset fishery production losses associated with the construction and operation of the Willamette Project. In most cases, hatchery facilities were built at or near the dam, and the hatchery program has continued to operate and release fish annually. From the time that Willamette Project dams were built and blocked migration upstream of the dam, a mix of returning natural-origin and hatchery-origin fish were likely captured at the base of the dam and incorporated into the hatchery broodstocks. As the natural-origin population declined in the following decades after the dams were built, the percentage of natural-origin fish incorporated into the broodstock likely also declined, with hatchery-origin fish making up the majority of the broodstock over the last decade or so. Since the hatchery broodstocks were originally founded from the local population, have likely incorporated natural-origin fish into the broodstock since the program was initiated, and with the existing broodstock being the only genetic resources available (in most populations, with the exception of the McKenzie) that might resemble the historical population, NMFS concluded hatchery Chinook salmon are part of the Willamette Chinook ESU (NMFS 2005c).

The above information is essential to consider with regard to the Proposed Action for the Chinook hatchery programs, the outplanting efforts for Chinook above the Project dams, and the following hatchery effects analyses. Since the existing broodstocks are part of the ESU and represent the only genetic remnants of the historical population, the SCAB group decided to use

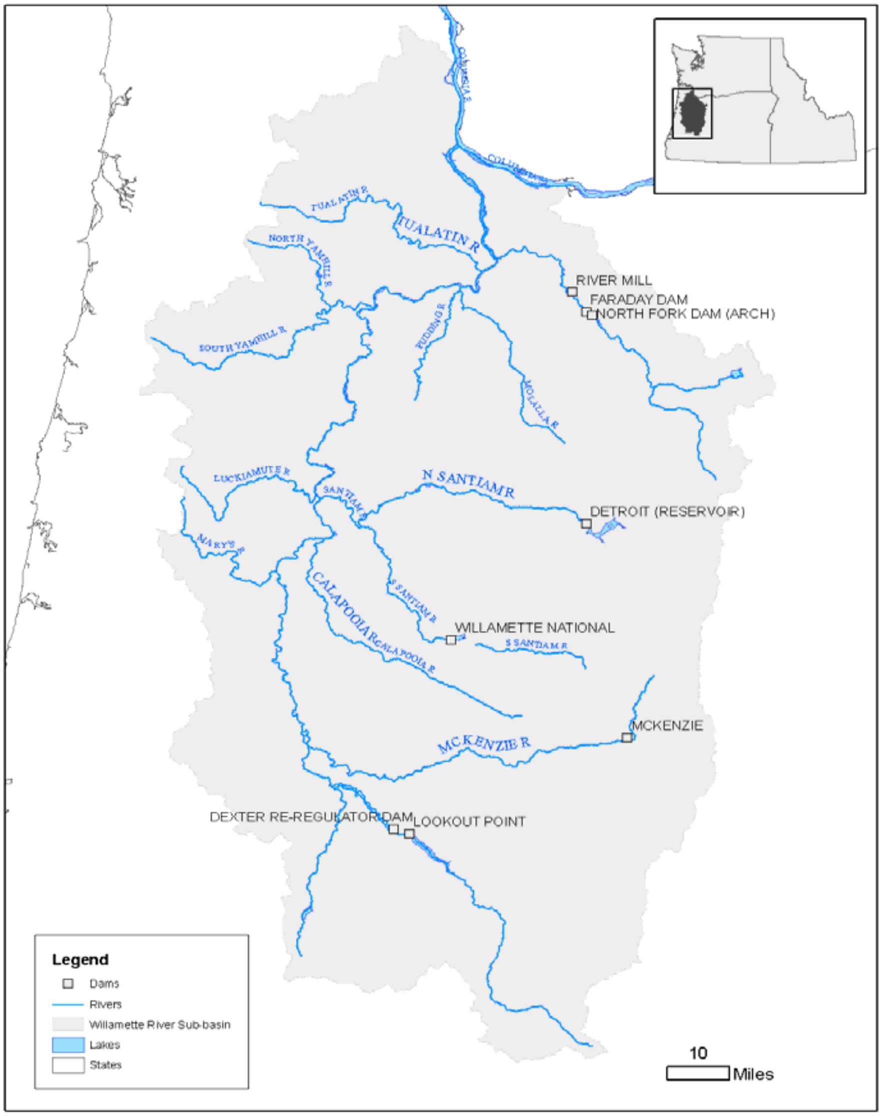
Willamette hatchery fish for reintroduction efforts above Project dams. The alternative would be to use only natural-origin returns (which in most cases are too few in number to make an improvement in population viability and would expose the natural-origin fish to high prespawn mortality and expose their progeny to very high downstream mortality rates through the reservoirs and dams). The SCAB group concluded in most cases it would be better to use the abundant hatchery fish until corrective actions could be implemented to improve adult and juvenile survival through the Willamette Project (Beidler and Knapp 2005). Hatchery fish could be used as a surrogate for natural-origin fish in order to gain a better understanding of the limiting factors affecting reintroduction above the dams.

ESU Management Perspective

At present, there are essentially two categories of populations in the Willamette spring Chinook ESU: 1) populations that are still relatively functional with recent returns of natural-origin fish numbering in the 1,000s (moderate to low risk of extinction; McKenzie and Clackamas), and 2) populations that have been significantly impacted with natural-origin returns at very low levels (very high risk of extinction; Middle Fork Willamette, Calapooia, South Santiam, North Santiam, Molalla).

Given this current situation, a range of hatchery management strategies will likely be necessary to accomplish the two primary hatchery management goals for this ESU: 1) minimize hatchery effects immediately in the two populations with relatively healthy runs and quality habitat that is still accessible (i.e. above Leaburg Dam on the McKenzie River and above North Fork Dam on the Clackamas River); and 2) use the hatchery program to help re-establish runs above currently impassable dams into historical habitat in specific populations where appropriate. Figure 5.1-1 shows an ESU perspective of the current management goals that have been identified for spring Chinook populations taking into account current status, key limiting factors and threats, and available genetic resources contained within existing hatchery stocks. Table 5.1-1 describes some of the short- and long-term actions that will be necessary to accomplish this hatchery management scenario.

Vision for Management of Willamette Hatchery Spring Chinook Programs



reintroduction area- hatchery fish (short term) and wild fish (short & long term)

mitigation hatchery program area with hatchery spawning managed according to population goals (long term)

Figure 5.1-1 Conceptual vision for the management of spring Chinook hatchery programs in the Willamette ESU. See Table 5.1-1 for further details on the management actions within each population area.

Table 5.1-1 Brief description of major hatchery management actions needed to help support achievement of a viable, self-sustaining ESU

TRT Population	Current extinction risk (from McElhany et al. 2007)	Hatchery Program Short term goals	 Long term goals
Clackamas Chinook	Moderate risk	Maintain <10-20% hatchery Chinook on the spawning grounds above North Fork dam until new sorting trap installed at appropriate dam.	Minimize hatchery influence to population above the dams. Allow <5% of the run above North Fork dam to be hatchery chinook. Headwater area will be wild fish sanctuary area to evaluate status of the run with minimial hatchery effects.
Molalla Chinook	Very high risk	Discontinue S. Santiam releases and develop locally derived stock for supplementation effort for 2-3 generations, or discontinue all hatchery releases and monitor if natural-origin returns increase.	Unknown at this time. Because the potential of this spring Chinook population is more limited than for "core" populations, it may be possible to have a harvest augmentation program in this river without much negative consequence on the recovery potential of the natural-origin run.
N. Santiam Chinook	Very high risk	Implement successful reintroduction program above Detroit dam with hatchery and natural fish returns. Fix problems with high prespawn mortality due to handling, transportation.	Phase out hatchery fish outplants above Detroit Dam once natural-origin returns are sufficient to maintain to sustain the population and promote local adaptation. The area above Detroit dam will be managed for natural-origin fish only once returns are sufficient and downstream passage is sufficiently fixed. The mitigation hatchery program will be confined to the area below Big Cliff dam.
S. Santiam Chinook	Very high risk	Continue to manage the proportion of hatchery fish outplanted with natural-origin fish above Foster Dam. Limit the hatchery proportion to 50% or less of the outplanted fish.	If natural-origin outplants above the dam continue to number greater than 500 fish, consider terminating all hatchery fish outplants so that this area can be used as a reference to evaluate the status of the natural-origin run above the dam and promote local adaptation. Need to be able to differentiate between NORs produced above and below Foster dam though.
Calapooia Chinook	Very high risk	Previous outplanting of adult chinook did not appear to be providing any benefit to the population because of high prespawn mortality rates. Habitat improvements are needed before the population is expected to recover.	Unknown at this time. If habitat improvements occur, a short-term hatchery supplementation may be bolster natural production. Otherwise, no hatchery program will likely exist in the Calapooia over the long term.
McKenzie Chinook	Moderate risk	Implement management actions to reduce the number of hatchery Chinook straying above Leaburg Dam.	Minimize hatchery effects above Leaburg Dam. Allow <5% of the run above Leaburg dam to be hatchery Chinook. Wild fish sanctuary area.
M.F. Willamette Chinook	Very high risk	Implement reintroduction program above Dexter/Lookout dams with hatchery and wild fish returns. Fix problems with high prespawn mortality due to handling, transportation.	Phase out hatchery fish outplants above Dexter/Lookout Point dams once natural-origin fish returns are sufficient to sustain the population and promote natural adaptation. The area above these dams will be managed for wild fish only once returns are sufficient and downstream passage is sufficiently fixed. The mitigation hatchery program will be confined to the area below Dexter dam.

Two important components in evaluating a hatchery program’s effects on natural-origin populations are: 1) the proportion of hatchery fish spawning in the natural-origin; and 2) the proportion of natural-origin fish incorporated into the hatchery broodstock. Sampling by ODFW since 2002, the first year when all returning hatchery Chinook had been marked before release, provides estimates of these key proportions (McLaughlin et al. 2008). These data are summarized in tables in sections 5.2.5, 5.3.5, 5.5.5, and 5.6.5, for each of the four Chinook populations in the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins, respectively. Other aspects of the hatchery program, such as residualism, competition, predation, and disease transfer are also important considerations. However, these aspects are nearly impossible to quantify on a site-specific basis, and effects are generally described qualitatively. Below is a summary of the two most important components of hatchery management in this ESU-managing hatchery fish on the spawning grounds and managing the hatchery broodstocks.

Hatchery Chinook on the Spawning Grounds

The Willamette/Lower Columbia (WLCTRT) and Interior Columbia TRT (ICTRT) have recommended very low levels of naturally spawning hatchery fish (i.e. <5% of the total) to ensure an ESU's natural viability. If hatchery fish comprise a substantial percentage of the natural spawners, the certainty that the population is truly self-sustaining is lowered. In addition, when evaluating recruits per spawner (productivity rates), large numbers of naturally spawning hatchery fish can substantially reduce the calculated productivity rates to <1 because hatchery fish are not naturally produced, indicating a non-viable population. The WLCTRT stated that viability targets/recovery goals must be greater if there are naturally spawning hatchery fish to account for the uncertainty in evaluating an ESU's true viability.

In the areas identified as "wild fish only" in Figure 5.1-1 above, the number of hatchery fish allowed to spawn naturally in the natural-origin fish production areas will be limited to the lowest extent possible in the near term. Over the long-term, there will have to be management solutions that will allow the percentage of naturally spawning hatchery fish to be controlled in order to evaluate the true status and viability of the natural population.

This is an issue for the "hatchery mitigation areas" (the area downstream of Willamette Project dams where some level of hatchery fish will always be present because the hatchery program was implemented to mitigate the effects of the dams) identified in Figure 5.1-1, above, since it may not be possible to strictly control the percentage of hatchery fish spawners below the dams. Additional management actions, such as additional harvest of hatchery fish, better homing to collection facilities, and/or production reductions, will probably be needed depending on the population. To illustrate this issue, take an example from the Middle Fork Willamette and North Santiam Rivers. In the Middle Fork Willamette, the long term hatchery mitigation area is identified in Figure 5.1-1, above, to be below Dexter Dam. This area is downstream of the "extreme range" of Chinook spawning identified by Mattson (1948). Thus, having the area below Dexter as a long-term hatchery mitigation area, which is comprised of mostly hatchery fish spawners, may not help the recovery prospects for this population (assuming reintroduction above the dam is successful). Information to date has shown little to no Chinook production below Dexter Dam even though there has been some spawning. Another example is in the North Santiam, where spawning of hatchery fish over the long term in the identified "hatchery mitigation area" is likely to be a significant issue. The principal spawning area for the historical population as identified by Mattson (1948) was the area one mile above Stayton to the mouth of the Breitenbush River. All of this area has been either blocked by dams and inundated by reservoirs or is directly downstream of the dams and negatively affected by Project operations. Having a high percentage of hatchery fish spawning in this historical principal spawning area may be a problem, especially if efforts to re-establish a portion of the population above the dams are not successful. Hatchery management changes would have to occur over the long term and/or the recovery targets will have to be higher to account for the uncertainty of knowing if the population is truly viable due to naturally spawning hatchery fish (WLCTRT and ODFW 2006). These two examples highlight that depending on the situation, even in the mitigation areas there may still be an adverse effect of allowing hatchery fish to spawn naturally over the long term.

Clackamas River

In the Clackamas River, trap and removal of hatchery fish at North Fork Dam has been somewhat successful over the past few years. PGE estimates less than 10% of the spring

Chinook upstream of North Fork Dam are hatchery fish. However, other information suggests that hatchery fish likely make up 10-30% of the run. PGE plans to upgrade the trapping facility at North Fork Dam as part of the FERC relicensing process so that all hatchery fish can be sorted and removed from the run with acceptable impacts to natural-origin fish. In the area downstream of North Fork Dam, the hatchery program will continue to operate so that mitigation responsibilities are fulfilled. In the recent past, some naturally spawning hatchery fish have been observed below the dam. However, this area was never the primary spring Chinook habitat in the basin. The low number of hatchery spawners should be of little consequence to the conservation and recovery of this population.

McKenzie River

In the McKenzie River, Leaburg Dam is the lower most facility on the river where hatchery fish can be removed. The goal at this dam has been to remove all hatchery fish passing Leaburg Dam so that the area upstream is for natural-origin fish only. However, in recent years, large numbers of hatchery and natural-origin fish have returned and removing large numbers of hatchery fish has not been feasible because of unacceptable impacts to the co-mingled natural-origin fish at the trap. In the next five years, the Action Agencies will need to take additional management actions to reduce the number of hatchery fish crossing Leaburg and/or improve the trapping facility to reduce impacts to natural-origin fish so that the area above Leaburg Dam will be for natural-origin Chinook only. This will reduce genetic risks from naturally spawning hatchery fish and allow evaluation of the true status of this natural-origin population without the masking effects of hatchery fish. Since the hatchery program will be confined to the areas below Leaburg Dam, any natural spawning of fish in this area will likely be predominately hatchery fish based on existing information. Significant numbers of hatchery fish have been observed spawning in this area since the time all returning hatchery fish have been marked. Further management actions to reduce and/or eliminate the number of hatchery spawners may be necessary to reduce hatchery masking effects. Increasing the harvest of hatchery fish in the lower McKenzie, improving fish homing fidelity back to the hatchery, and/or improved water flow attractants to the hatchery have been discussed among the co-managers (ODFW, USACE, BPA, EWEB, NMFS, USFWS) to address the issue of significant numbers of naturally-spawning hatchery fish in the McKenzie River. Reducing or eliminating the current production of McKenzie hatchery Chinook is also an option to be considered, as long as mitigation obligations can still be fulfilled.

Calapooia River

The Calapooia River is also identified as a wild fish only population in this conceptual vision (Figure 5.1-1). In the recent past, some hatchery adults have been outplanted to this river in hopes of providing more spawners. However, monitoring has shown very high prespawning mortality (and possibly poaching). Consequently, very few spawners have been observed. It is unlikely that hatchery fish outplants will provide much benefit to this population in the near term, while habitat restoration may be critical. Termination of hatchery outplants will allow natural recolonization to be monitored as habitat is recovered. Hatchery fish outplanting may be initiated again at a later time, if deemed appropriate.

North Santiam, South Santiam & Middle Fork Willamette Rivers

In the North Santiam, South Santiam, and Middle Fork Willamette where dams have eliminated most if not all of the historical spring Chinook habitat, the hatchery programs will be managed to help reintroduce runs above the dams. The current hatchery programs were initiated when the dams were built. The hatcheries are located at the base of the impassable dam and thus have likely incorporated fish from the historical run into the hatchery broodstocks. The hatchery programs in each of the populations are most likely the best remaining genetic resources of the historical runs above the dams that are still available. There have undoubtedly been some genetic and phenotypic changes with the hatchery stock; however the current hatchery stock is the only remnant of what might have historically existed in these populations.

Natural-origin fish returns in each of these populations have been dismal since 2000, when all returning hatchery fish have been marked and direct estimates of the number of naturally produced fish could finally be obtained. The poor returns of natural fish are attributed to poor production below the dams. It is also important to note the overall returns (predominately hatchery fish) to the Willamette River during these years were some of the largest observed in the last 20-30 years. The approach for using hatchery fish to re-establish runs above the dams in these three populations would be to outplant primarily adult Chinook salmon into the vacant habitats above the dams. Adequate numbers of hatchery fish that are surplus to broodstock needs are typically available every year to provide enough fish to seed habitat above the dams. Outplanting adult hatchery fish would likely have to continue for at least 10 years (two generations) given the problems that have been identified to date with trap and haul, prespawning mortality, and downstream passage. These hatchery fish can also be used for research purposes to monitor the downstream survival of fish through the reservoirs, turbines, and regulating outlets. Given the extremely low returns of natural-origin fish to these populations, it may not be prudent to use the few natural-origin fish returning as the research group to monitor and experiment with fish survival through the dams and reservoirs. Over time, as natural origin returns hopefully start to increase from these reintroduction efforts and return to the base of the dams, these natural origin fish will comprise most of the outplanted fish above the dams with the hatchery component becoming less and less. A successful reintroduction program above the dam would be when only natural-origin fish are outplanted above the dam with no hatchery fish supplementation. Further details on these reintroduction efforts using the hatchery programs are being discussed and formalized by the comanagers.

In order to evaluate the success or failure of this outplanting program, a well developed monitoring and evaluation program will need to be implemented to track hatchery supplementation and hatchery fish performance as it relates to population abundance, productivity, fitness, and survival. Currently, little to no information is available on the status of Chinook above the projects in these rivers. There are many agencies that have a stake in the outcome of this program that should help fund the comprehensive monitoring and evaluation program.

It is important to stress that the success of this hatchery outplanting program depends ultimately on whether additional actions will be taken to improve fish survival through Project dams and reservoirs and maintaining and improving spawning and rearing habitat in the river basins. The hatchery supplementation program alone will not accomplish the goal of a self-sustaining, naturally-produced population of spring Chinook without additional corrective actions in "Habitat" and "Hydro" limiting factors. If the habitat is bad and fish survival through the dams and reservoirs is poor, it would not matter how many hatchery fish are outplanted year after year above the projects.

Molalla River

The status of the spring Chinook run in the Molalla is similar to the Calapooia River. The overall numbers of redds observed in recent years has been low and most of the fish spawning are of hatchery origin. It is unknown at this time whether continued releases of an out of population hatchery stock is benefiting the conservation and recovery of this population, whether a new broodstock should be developed, or if hatchery fish releases should be discontinued altogether. Preliminary discussions have occurred among ODFW, NMFS, and non-governmental organizations to sort out these issues. It is clear that continuing the existing hatchery program will not improve the status of this population without significant habitat improvements in the Molalla Basin.

Management of Chinook Broodstocks

All of the current Chinook hatchery programs are part of the ESU. The HGMPs are proposing to manage Chinook broodstocks as an integrated stock, where natural-origin fish are purposefully incorporated into the broodstock on a regular basis. Since many of the hatchery programs will play an important role in re-establishing runs above the impassable dams back into historical habitat, it is crucial to have an integrated hatchery stock for supplementation purposes (HSRG 2004). Sliding scale broodstock matrices are described in the HGMPs and specify the desired percentage of natural-origin fish to be incorporated into hatchery broodstocks. For the populations where hatchery fish spawning in the wild will be managed to low levels (e.g. McKenzie above Leaburg Dam), natural-origin fish are being incorporated into the broodstock to minimize divergence between the hatchery and natural-origin stocks, and thus further reducing the effects of hatchery fish.

5.1.5.1.2 Summer Steelhead Hatchery Program

In the Willamette Basin, there is a mitigation obligation by the Action Agencies to fund hatchery production of steelhead to mitigate for the effects of the construction and operation of the Willamette Project on winter steelhead (USACE 2007a). In the past, ODFW operated a winter steelhead hatchery program. However, this program was discontinued in the late 1990s. ODFW choose to have the mitigation production be all hatchery summer steelhead.

The purpose of the summer steelhead hatchery program is solely harvest augmentation in recreational fisheries. There is no conservation value of this program for winter steelhead. Long term management of this program is focused on reducing the effects of these summer steelhead on winter steelhead in the North and South Santiam populations. Presently, the primary concern with this hatchery program is the natural spawning of stray summer steelhead in winter steelhead habitat (Schroeder et al. 2006). In the short term, reform actions are necessary to reduce the potential impacts of this program. Additional monitoring and evaluation tasks will be implemented to help identify the extent of natural spawning and if offspring are being produced. This information will help inform future management of this program.

5.1.5.1.3 Resident Rainbow Trout Hatchery Program

At present, the McKenzie River is the only area where hatchery trout are stocked for put-and-take fisheries in free flowing waters. Trout are stocked in nearly all of the reservoirs. The intent is to minimize stocking of trout in salmon and steelhead habitat.

5.1.5.2 General Effects of Hatchery Programs on Salmon & Steelhead

In the Willamette Basin, the Action Agencies are proposing to continue to artificially propagate spring Chinook salmon, summer steelhead, and resident rainbow trout. All of these programs can affect listed salmon and steelhead in the following ways. Below is a discussion of the general factors to be considered when evaluating the effects of hatchery programs on ESA listed salmon and steelhead. The population-specific effects of the hatchery programs are discussed in the appropriate subbasin below.

5.1.5.2.1 Hatchery Operations

Potential risks to listed natural salmonids associated with the operation of hatchery facilities include:

1. Hatchery facility failure (power or water loss leading to catastrophic fish losses).
2. Hatchery water intake impacts (stream de-watering and fish entrainment).
3. Hatchery effluent discharge impacts (deterioration of downstream water quality).

The actual impacts that hatchery facility operations can have on listed fish depend on the likelihood that the hatchery operation will interact with juvenile or adult fish, and whether the program is operated to minimize the risk of adverse impacts on listed fish.

Hatchery Facility Failure

This risk is of particular concern when facilities rear listed species, but must be addressed to ensure meeting program goals and objectives. Factors such as flow reductions, flooding and poor fish culture practices may all cause hatchery facility failure or the catastrophic loss of fish under propagation. The following measures are considered important in reducing the risk of catastrophic loss resulting from propagation facility failures:

- Minimizing the time adult fish are held in traps.
- Minimizing hatchery facility failure through on-site residence by hatchery personnel to allow rapid response to power or facility failures.
- Using low pressure/low water level alarms for water supplies to notify personnel of water emergencies.
- Installing back-up generators to respond to power loss.
- Training all hatchery personnel in standard fish propagation and fish health maintenance methods.

Hatchery Water Intake Impacts

Water withdrawals for those hatcheries within spawning and rearing areas can diminish stream flow, impeding migration and affecting the spawning behavior of listed fish. Water withdrawals may also affect other stream-dwelling organisms that serve as food for juvenile salmonids by reducing habitat, and through displacement and physical injury. Unscreened or inadequately screened hatchery intakes entrain aquatic biota, including fish. Entrainment means that the fish are likely to perish. Older hatchery intakes are often inadequately screened, and may present entrainment hazards. Fish may become impinged on the screens due to larger than current criterion screen openings, or velocities higher than the current criterion. While USACE Willamette Project hatcheries return most of their diverted water back to the stream, there is often significant flow reduction between diversion and water return. The risks associated with water withdrawals can generally be minimized by complying with water right permits and meeting NMFS' screening criteria (NMFS 2000c). These screening criteria for water withdrawal devices set forth conservative standards that help minimize the risk of harming naturally produced salmonids and other aquatic fauna. These risks can also be reduced through the use of well water sources for the operation of all or portion of the facility production.

Hatchery Effluent Discharge Impacts

Effluent discharges can change water temperature, pH, suspended solids, ammonia, organic nitrogen, total phosphorus, and chemical oxygen demand in the receiving stream's mixing zone (Kendra 1991). It is usually not known how a hatchery's effluent affects listed salmonids and other stream-dwelling organisms. The level of impact depends on the amount of discharge and the flow volume of the receiving stream. Any adverse impacts probably occur at the immediate point of discharge, because effluent dilutes rapidly. The Clean Water Act requires hatcheries (i.e. "aquatic animal production facilities") with annual production greater than 20,000 lbs to obtain a National Pollutant Discharge Elimination System (NPDES) permit in order to discharge hatchery effluent to surface waters. These permits are intended to protect aquatic life and public health and ensure that every facility treats its wastewater. The impacts from the releases are analyzed and the permits set site-specific discharge limits and monitoring and reporting requirements. Variations from permitted discharge levels are subject to enforcement actions (EPA 1999). In addition, hatcheries in the Columbia River Basin operate under the policies and guidelines developed by the Integrated Hatchery Operations Team (IHOT 1995) to reduce hatchery impacts on listed fish. Impacts on listed salmon and steelhead are minimized by requiring all hatchery effluents to meet the discharge limits in their respective NPDES permits and by meeting IHOT guidelines.

5.1.5.2.2 Broodstock Collection

Broodstock collection can affect listed salmonids through the method of collection and by the removal of adults from the spawning population.

Collection Method

There are a number of methods for collecting salmonid broodstock including taking spawners as they return to the hatchery and using a weir or a fish ladder-trap combination at a barrier such as a dam. These devices effectively block upstream migration and force returning adult fish to enter a trap-and-holding area. Trapped fish are counted and either retained for use in the hatchery or released to spawn naturally. The physical presence of a weir or trap can affect salmonids by:

- Delaying upstream migration;
- Causing the fish to reject the weir or fishway structure, thus inducing spawning downstream of the trap (displaced spawning);
- Contributing to fallback of fish that have passed above the weir; and
- Injuring or killing fish when they attempt to jump the barrier (Hevlin and Rainey 1993; Spence et al. 1996).
- Affecting the spatial distribution of juvenile salmon and steelhead seeking preferred habitats.

Impacts associated with operating a weir or trap include:

- Physically harming the fish during their capture and retention whether in the fish holding area within a weir or trap, or by the snagging, netting or seining methods used for certain programs;
- Harming fish by holding them for long durations;
- Physically harming fish during handling; and
- Increasing their susceptibility to displacement downstream and predation, during the recovery period.

The proper design and operation of the weirs and traps can reduce many of their potential negative impacts (see Hevlin and Rainey 1993). The installation and operation of weirs and traps are very dependent on water conditions at the trap site. High flows can delay the installation of a weir or make a trap inoperable. A weir or trap is usually operated in one of two modes. Continuously – where up to 100 percent of the run is collected and those fish not needed for broodstock are released upstream to spawn naturally, or periodically – where the weir is operated for a number of days each week to collect broodstock and otherwise left opened to provide fish unimpeded passage for the rest of the week. The mode of operation is established during the development of site-based broodstock collection protocols and can be adjusted based on in-season escapement estimates and environmental factors.

The potential impacts of weir rejection, fallback and injury from the operation of a weir or trap can be minimized by allowing unimpeded passage for a period each week. Trained hatchery personnel can reduce the impacts of weir or trap operation, by removing debris, preventing poaching and ensuring safe and proper facility operation. Delay and handling stress may also be reduced by holding fish for the shortest time possible, less than 24 hours and any fish not needed for broodstock should quickly be allowed to recover from handling and be immediately released upstream to spawn naturally. However, it may be necessary to hold fish longer at the beginning and the end of the trapping season when the adult numbers are low.

Beach seines, hook and line, gillnets and snorkeling are other methods used to collect adult broodstock for artificial production programs. All these methods can adversely affect listed fish through injury, delaying their migration, changing their holding and spawning behavior, and increasing their susceptibility to predation and poaching. Some artificial production programs collect juveniles for their source of broodstock. Programs can collect developing eggs or fry by hydraulically sampling redds or collected emerging juvenile fish by capping redds (Young and Marlowe 1995; Shaklee et al. 1995; WDFW et al. 1995; WDFW 1998). Seines, screw traps and hand nets can also be used to collect juveniles. Each of these methods can adversely affect listed fish through handling or harming the juvenile fish that remain.

Adult Removal

The removal of adults from a naturally-spawning population has the potential to reduce the size of the natural population (sometimes called “mining”), cause selection effects, and remove nutrients from upstream reaches (Spence et al. 1996; NRC 1996; Kapusinski 1997). In cases where listed salmonid populations are not even replacing themselves and a supplementation hatchery program can slow trends toward extinction and buy time until the factors limiting population viability are corrected, risks to the natural population, including numerical reduction and selection effects, are in some cases subordinate to the need to expeditiously implement the artificial production programs that will reduce the likelihood of extinction in the short term of the populations and potentially the ESU (i.e., Redfish Lake sockeye).

5.1.5.2.3 Genetic Introgression

A defining characteristic of anadromous salmonids is their high fidelity to their natal streams. Their ability to home with great accuracy and maintain high fidelity to natal streams has encouraged the development of locally adapted genetic characteristics that allow the fish to use specific habitats. The genetic risks that artificial propagation pose to naturally produced populations can be separated into reductions or changes in the genetic variability (diversity) among and within populations (Hard et al. 1992; Cuenco et al. 1993; NRC 1996; Waples 1996).

Loss of Diversity Among Populations

Genetic differences among salmon populations arise as a natural consequence of their homing tendency. Homing leads to a relatively high degree of demographic isolation among populations. This demographic isolation produces conditions where evolutionary forces such as natural selection and random genetic drift create differences in allele frequencies among populations. Many of these differences are believed to be adaptive – meaning that populations have been shaped by natural selection to have a particularly good fit to their local environment (see Taylor 1991 and McElhany et al. 2000 for reviews).

Hatchery activities can threaten the natural genetic diversity among salmon populations in several different ways. For example, many hatcheries have historically bred and released salmon that were not native to the drainage into which they were released. If these fish stray and breed with native salmon the unique genetic attributes of the local salmon populations can be degraded or lost. Genetic diversity can also be lost by hatchery practices that lead to excessive straying of hatchery fish, or by collecting mixtures of genetically discrete populations for use as hatchery broodstock.

Excessive gene flow into a natural population from naturally spawning hatchery fish can reduce the fitness of individual populations through a process called outbreeding depression. Outbreeding depression arises because natural salmonid populations adapt to the local environment and this adaptation is reflected in the frequency of specific alleles that improve survival in that environment. When excessive gene flow occurs, alleles that may have developed in a different environment are introduced and these new alleles may not benefit the survival of the receiving population leading to outbreeding depression.

Another source of outbreeding depression is the loss of combinations of alleles called coadapted complexes. Gene flow can introduce new alleles that can replace alleles in the coadaptive complexes leading to a reduction in performance (Busack and Currens 1995). Outbreeding depression from gene flow can occur when eggs and fish are transferred among populations and/or when out of basin hatchery populations are released to spawn with the local population.

There is evidence for local adaptation of salmonid populations (see Taylor 1991 and McElhany et al. 2000 for reviews), but the only empirical data on outbreeding depression in fish involves distantly related populations (Busack and Currens 1995). Pacific Northwest hatchery programs historically contributed to the loss of genetic diversity among populations through the routine transfer of eggs and fish from different hatchery populations. Such practices are no longer routine and in fact are being restricted through management policy (see Table 15). The release of hatchery fish into populations different from the introduced fish has also resulted in gene flow above natural levels (genetic introgression), reducing the genetic diversity among populations. Research based primarily on findings in the Kalama River, Washington, for summer-run steelhead has suggested that interbreeding between non-indigenous Skamania hatchery stock steelhead (a highly domesticated, hatchery stock) and native naturally produced fish may have negatively affected the genetic diversity and long term reproductive success of naturally produced steelhead (Leider et al. 1990; Hulett et al. 1996). Non-indigenous hatchery and native naturally produced steelhead crosses may be less effective at producing adult off-spring in the natural environment compared to naturally produced fish (Chilcote et al. 1986, Chilcote1998; Blouin 2004).

Campton (1995) examined the risks of genetic introgression to naturally produced fish and suggested the need to distinguish the biological effects of hatcheries and hatchery fish from the indirect and biologically independent effects of fisheries management actions. In his review of the scientific literature for steelhead, he suggested that many of the genetic effects detected to date appear to be caused by fisheries management practices such as stock transfers and mixed stock fisheries and not by biological factors intrinsic to hatchery fish (Campton 1995). However, loss of among population genetic diversity as a result of these types of hatchery practices has been documented for western trout, where unique populations have been lost through hybridization with introduced rainbow trout (Behnke 1992). Phelps et al. (1994) found evidence for introgression of non-native hatchery steelhead into a number of natural populations within the southwest Washington region. However, in other areas where hatchery production has been extensive, native steelhead genotypes have been shown to persist (Phelps et al. 1994; Narum et al. 2006).

The loss of genetic variability among populations can be minimized by:

- Propagating and releasing only fish from the local indigenous population or spawning aggregate.
- Avoiding or adequately reducing, gene-flow from a hatchery program into a natural population.
- Limiting the transfers of fish between different areas.
- Acclimate hatchery fish in the target watershed to ensure high fidelity to the targeted stream.
- Using returning spawners rather than the transferred donor population as broodstock for restoration programs to foster local adaptation.
- Maintaining natural populations that represent sufficient proportions of the existing total abundance and diversity of an ESU/DPS without hatchery intervention.
- Visually marking all hatchery-produced salmonids to allow for monitoring and evaluation of straying and contribution to natural production (Kapuscinski and Miller 1993; Flagg and Nash 1999).

A NMFS-sponsored workshop in 1995, focused on the biological consequences of hatchery fish straying into natural salmonid populations (Grant 1997). The workshop addressed how much gene flow can occur and still remain compatible with the long-term conservation of local adaptations and genetic diversity among populations. Based on selection effects in other animals, a gene flow rate of greater than 5 percent between local and non-local populations would quickly lead to replacement of neutral and locally-adapted genes (Grant 1997). NMFS notes that gene flow is expected to be much less than 5 percent when the stray rate of non-local fish into a local population is 5 percent because not all fish that stray will spawn successfully. Thus, NMFS supports the standard that hatchery stray rates should be managed such that less than 5 percent of the naturally spawning population consists of hatchery fish from a different area. Furthermore, the number of non-local strays in a particular population should be as low as possible to minimize genetic introgression.

This approach has been applied by the ICTRT and WLCTRT in their development of population viability criteria for the recovery of listed species (ICTRT 2007; WLCTRT and ODFW 2006). The ICTRT (2007) developed a flow-chart approach to assigning risk associated with exogenous spawners in the salmon population (they define exogenous spawners as all hatchery-origin and all natural-origin fish that are present due to unnatural, anthropogenically induced conditions (Figure 5.1-2). The WLCTRT developed similar metrics to describe risk to the diversity of listed populations, including one measuring the potential loss of fitness over time (Figure 3b and 3c in WLCTRT and ODFW 2006) that is based on the Proportion of Natural Influence (PNI). PNI is defined as the relationship between the percent of hatchery-origin fish spawning naturally and the percent of natural-origin fish in the hatchery broodstock (see HSRG 2004). Another metric for diversity looked at the influence of non-local origin fish strays, both within ESU and out-of-ESU, on diversity, but considered these strays only if there was evidence of interbreeding (WLCTRT and ODFW 2006).

As with the ICTRT, the WLCTRT combined these and other metrics together to develop a score for the diversity criteria, used to determine the overall viability of a population. The methods for weighing the different metrics within the criteria and developing a final combined score have not been finalized. It should also be noted that the failure in one of the metrics (e.g. loss of fitness over time) does not prevent the population from meeting the diversity criteria.

As described previously, NMFS has identified two general types of hatchery programs: isolated (or segregated) and integrated. The optimal proportion of hatchery fish spawning naturally depends on the type of program and the status of the natural spawning population. For isolated hatchery programs, the management goal is to minimize the number of naturally spawning hatchery fish and the number should not exceed 5 percent of the naturally spawning population (Mobrand et al. 2005). For supplementation programs, the level of hatchery spawners in the naturally spawning population should be based on the level of gene flow from the natural environment to the hatchery environment, i.e., the PNI goal for the program. The strength of that gene flow should be determined by the status of the natural-origin population and its importance to recovery.

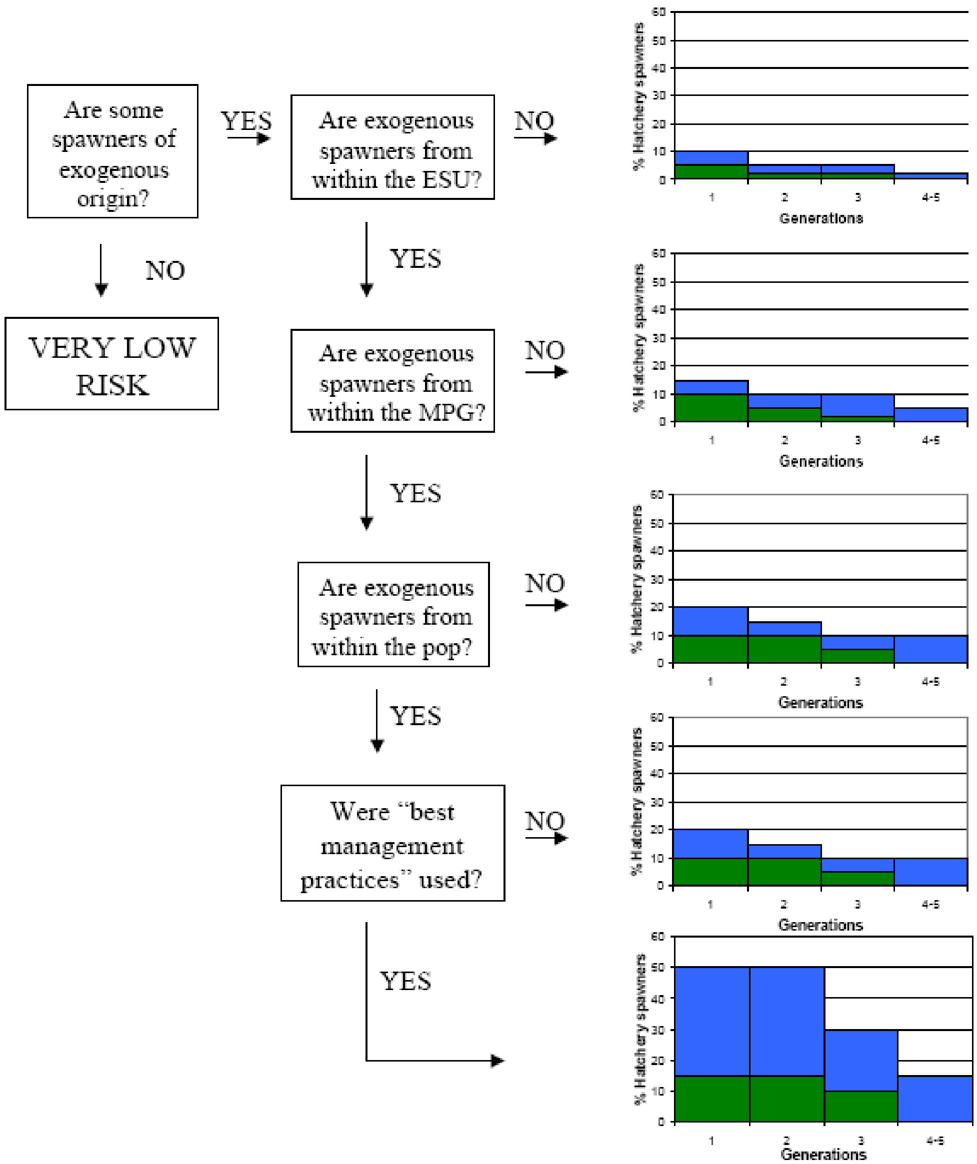


Figure 5.1-2 Graphical representation of risk criteria associated with spawner composition.

Green areas indicate low risk combinations of duration and proportion of spawners, blue areas indicate moderate risk areas and red-striped areas and areas outside the range graphed indicate high risk. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin (ICTRT 2007).

Loss of Diversity Within Populations

Loss of within population genetic diversity due to artificial propagation is caused by:

- genetic drift,
- inbreeding depression, and/or
- domestication selection.

Loss of within population genetic diversity (variability) is defined as the reduction in quantity, variety and combinations of alleles in a population (Busack and Currens 1995). Quantity is defined as the proportion of an allele in the population and variety is the number of different kinds of alleles in the population.

Genetic Drift

Genetic diversity within a population can change from random genetic drift and from inbreeding. Random genetic drift occurs because the progeny of one generation represents a sample of the quantity and variety of alleles in the parent population. Since the next generation is not an exact copy of the parent generation, rare alleles can be lost, especially in small populations where a rare allele is less likely to be represented in the next generation (Busack and Currens 1995).

The process of genetic drift is governed by the *effective population size* rather than the observed number of breeders. The effective size of a population is defined as the size of an idealized population that would produce the same level of inbreeding or genetic drift seen in an observed population of interest (Hartl and Clark 1989). Attributes of such an idealized population typically include discrete generations, equal sex ratios, random mating and specific assumptions about the variance of family size. Real populations almost always violate one or more of these idealized attributes, and the effective size of a population is therefore almost always smaller than the observed census size. Small effective population size in hatchery programs can be caused by:

- Using a small number of adults for hatchery broodstock.
- Using more females than males (or males than females) for the hatchery broodstock.
- Pooling the gametes of many adults during spawning which would allow one male to potentially dominate during fertilization.
- Changing the age structure of the spawning population from what would have occurred naturally.
- Allowing progeny of some matings to have greater survival than allowed others (Gharrett and Shirley 1985; Simon et al. 1986; Busack and Currens 1995; Waples 1991; Campton 1995).

Some hatchery stocks have been found to have less genetic diversity and higher rates of genetic drift than some naturally produced populations, presumably as a result of a small effective number of breeders in the hatcheries (Waples et al. 1993). Potential, negative impacts of artificial propagation on within population diversity may be indicated by changes in morphology (Bugert et al. 1992) or behavior of salmonids (Berejikian 1996). Busack and Currens (1995) observed that it would be difficult to totally control random loss of within population genetic diversity in hatchery populations, but by controlling the broodstock number, sex ratios, and age structure, loss could be minimized. Theoretical work has demonstrated that hatcheries can reduce the effective size of a natural population in cases where a large number of hatchery strays are produced by a relatively small number of hatchery breeders (Ryman et al. 1995). This risk can be minimized by having hatcheries with large effective population sizes and by controlling the rate of straying of hatchery fish into naturally produced populations.

Inbreeding Depression

The breeding of related individuals (inbreeding) can change the genetic diversity within a population. Inbreeding *per se* does not lead directly to changes in the quantity and variety of alleles but can increase both individual and population homozygosity. This homozygosity can change the frequency of phenotypes in the population which are then acted upon by the environment. If the environment is selective towards specific phenotypes then the frequency of alleles in the population can change (Busack and Currens 1995). Increased homozygosity is also often expected to lead to a reduction in fitness called *inbreeding depression.* Inbreeding depression occurs primarily because nearly all individuals harbor large numbers of deleterious alleles whose effects are masked because they also carry a non-deleterious ‘wild type’ allele for the same gene. The increased homozygosity caused by inbreeding leads to a higher frequency of individuals homozygous for deleterious alleles, and thus a reduction in the mean fitness of the population (see Waldman and McKinnon 1993 for a review).

It is important to note that there is little empirical data on inbreeding depression or substantial loss of genetic variability in any natural or hatchery population of Pacific salmon or steelhead, although there are considerable data on the effects of inbreeding in rainbow trout (Myers et al. 1998). Studying inbreeding depression is particularly difficult in anadromous Pacific salmon because of their relatively long generation times, and the logistical complexities of rearing and keeping track of large numbers of families. Monitoring the rate of loss of molecular genetic variation in hatchery and naturally-produced populations is one alternative method for studying the impacts of hatcheries on genetic variability (Waples et al. 1993), but does not provide information on inbreeding depression or other fitness effects associated with changes in genetic variation. Many of these changes are also expected to occur over many generations, so long term monitoring is likely to be necessary to observe all but the most obvious changes.

The impacts of inbreeding between hatchery and natural stocks can be minimized following an isolated hatchery strategy by:

- Releasing fewer or no hatchery fish into the natural population.
- Releasing hatchery fish only at the hatchery or at locations where they are unlikely to interbreed with natural fish when returning as adults.
- Advancing or retarding the time of spawning for hatchery fish, to minimize the overlap in spawning time between hatchery and natural fish.
- Acclimating hatchery fish prior to release to improve homing precision.
- Acclimating and releasing hatchery fish at locations where returning adults can be harvested at high rates (harvest augmentation programs), locations away from natural production areas and sites where returning adults can be sorted and removed from the spawning population.

Domestication Selection

Domestication means changes in quantity, variety and combination of alleles between a hatchery population and its source population that are the result of selection in the hatchery environment (Busack and Currens 1995). Domestication is also defined as the selection for traits that favor survival in a hatchery environment and that reduce survival in natural environments (NMFS 1999d). Domestication can result from rearing fish in an artificial environment that imposes different selection pressures than what they would encounter in the wild. The concern is that domestication effects will decrease the performance of hatchery fish and their descendants in the wild. Busack and Currens (1995) identified three types of domestication selection (1) intentional or artificial selection, (2) biased sampling during some stage of culture, and (3) unintentional or relaxed selection.

(1) Intentional or artificial selection is the attempt to change the population to meet management needs, such as time of return or spawning time. Hatchery fish selected to perform well in a hatchery environment tend not to perform well when released into the wild, due to differences between the hatchery and the naturally produced populations resulting from the artificial propagation. Natural populations can be impacted when hatchery adults spawn with natural-origin fish and the performance of the natural population is reduced (a form of outbreeding depression) (Busack and Currens 1995).

(2) Biased sampling leading to domestication can be caused by errors during any stage of hatchery operation. Broodstock selection is a common source of biased sampling when adults are selected based on particular traits. Hatchery operations can be a source of biased sampling when groups of fish are selected against when feeding, ponding, sorting and during disease treatments because different groups of fish will respond differently to these activities.

(3) Genetic changes due to unintentional or relaxed selection occur because salmon in hatcheries usually have (by design) much higher survival rates than they would have in the wild. Hatchery fish are reared in a sheltered environment that increases their survival relative to similar life stages in the natural environment allowing deleterious genotypes that would have been lost in the natural environment to potentially contribute to the next generation.

Reisenbichler and Rubin (1999) cite five studies indicating that hatchery programs for steelhead and stream-type Chinook salmon (i.e., programs holding fish in the hatchery for one year or longer) genetically change the population and thereby reduce survival for natural rearing. The authors report that substantial genetic change in fitness can result from traditional artificial propagation of salmonids held in captivity for one quarter or more of their life. Bugert et al. (1992) documented morphological and behavioral changes in returning adult hatchery spring Chinook salmon relative to natural adults, including younger age, smaller size, and reduced fecundity. However, since that study, differences in size and age at return have been found to be more related to smolt size at release than domestication selection. Differences in fecundity are still observed, but not fully understood.

Leider et al. (1990) reported diminished survival and natural reproductive success for the progeny of non-native hatchery steelhead when compared to native naturally produced steelhead in the lower Columbia River region. The poorer survival observed for the naturally produced offspring of hatchery fish could have been due to the long term artificial and domestication selection in the hatchery steelhead population, as well as maladaptation of the non-indigenous hatchery stock in the recipient stream (Leider et al. 1990). Ongoing research on winter steelhead in the Hood River basin (Blouin 2004; Araki and Blouin 2005) compared the reproductive success of hatchery and natural-origin adults. The old program, that used out-of-basin broodstock, was determined to be 17 to 54 percent as reproductively successful as the natural-origin adults. The new program used natural-origin winter steelhead adults for broodstock, and their progeny were determined to be 85 to 108 percent as successful as natural-origin adults in producing adult returns to the basin. These results do not support the assumption of domestication selection in first generation of hatchery rearing for steelhead.

Chilcote (1998) reported a strong negative correlation between the proportion of naturally spawning hatchery steelhead and stock productivity, when examining spawner-recruit relationships for 26 Oregon steelhead populations. Based on the best scientific information, the NMFS FCRPS biological opinion assumed a relative reproductive success range of 20 percent to 80 percent for naturally spawning hatchery-origin fish compared to naturally produced fish (NMFS 2000b).

Berejikian (1996) reported that natural-origin steelhead fry survived predation by prickly sculpins (*Cottus asper*) to a statistically significant degree better than size-matched off-spring of locally-derived hatchery steelhead that were reared under similar conditions. Alteration of the innate predator avoidance ability through domestication was suggested by the results of this study. However, Joyce et al. (1998) reported that an Alaskan spring Chinook salmon stock under domestication for four generations did not significantly differ from offspring of naturally produced spawners in their ability to avoid predation. The domesticated and naturally produced Chinook salmon groups tested also showed similar growth and survival rates in freshwater performance trials.

- Domestication effects from artificial propagation and the level of genetic differences between hatchery and natural fish can be minimized by:
- Randomly selecting adults for broodstock from throughout the natural population migration to provide an unbiased sample of the natural population with respect to run timing, size, age, sex ratio, and other traits identified as important for long term fitness.
- Ensuring that returning adults used as broodstock by a hatchery continually incorporate natural-origin fish over the duration of the program to reduce the likelihood for divergence of the hatchery population from the natural population.
- Limiting the duration of a supplementation program to a maximum of three salmon generations (approximately 12 years) to minimize the likelihood of divergence between hatchery broodstocks and target natural stocks and to reduce the risk of domestication of the composite hatchery/natural stock.
- Employing appropriate spawning protocols to avoid problems with inbreeding, genetic drift and selective breeding in the hatchery (Simon et al. 1986; Allendorf and Ryman 1987; Gall 1993). Methods include collection of broodstock proportionally across the breadth of the natural return, randomizing matings with respect to size and phenotypic traits, application of at least 1:1 male to female mating schemes (Kapuscinski and Miller 1993), and avoidance of intentional selection for any life history or morphological trait.
- Using spawning protocols that equalize as much as possible the contributions of all parents to the next breeding generation.
- Using only natural fish for broodstock in the hatchery each year to reduce the level of domestication.

- Setting minimum broodstock collection objectives to allow for the spawning of the number of adults needed to minimize the loss of some alleles and the fixation of others (Kapuscinski and Miller 1993).
- Setting minimum escapements for natural spawners and maximum broodstock collection levels to allow for at least 50 percent of escaping fish to spawn naturally each year, to help maintain the genetic diversity of the donor natural population.
- Using hatchery methods that mimic the natural environment to the extent feasible (e.g. use of substrate during incubation, exposure to ambient river water temperature regimes and structure in the rearing ponds).
- Limiting the duration of rearing in the hatchery by releasing at early life-stages to minimize the level of intervention into the natural salmonid life cycle, minimizing the potential for domestication.

NMFS believes that the measures identified for minimizing the potential adverse genetic impacts of hatchery produced fish on naturally produced fish should be applied to protect listed species. The actual measures selected will depend on a number of factors including but not limited to:

- The objectives of the program (i.e. recovery, reintroduction or harvest augmentation).
- The source of the broodstock, its history and level of domestication.
- The spawning protocols proposed for the hatchery program.
- The status of the natural population targeted by the hatchery program.
- The ability of fish managers to remove or control the number of hatchery adults in the natural spawning population.
- The proposed rearing practices for the hatchery program.
- The total number of hatchery fish released into the subbasin.

More detailed discussions on the measures to implement these strategies can be found in Reisenbichler (1997), Reisenbichler and McIntyre (1986), Nelson and Soule (1987), Hindar et al. (1991), and Waples (1991) among others.

Genetic introgression is the primary concern regarding the proposed artificial propagation programs. Specific impacts and measures to minimize these impacts for all of the proposed programs will be discussed in Section 4.2 of this opinion.

5.1.5.2.4 Disease

Hatchery effluent has the potential to transport fish pathogens out of the hatchery, where natural fish may be exposed to infection. Interactions between hatchery fish and natural fish in the environment may also result in the transmission of pathogens, if either the hatchery or natural fish are harboring fish disease. This latter impact may occur in tributary areas where hatchery fish are released and throughout the migration corridor where hatchery and naturally produced fish may interact. As the pathogens responsible for fish diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the source of the pathogen (Williams and Amend 1976; Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that increase stress and can lead to greater manifestation and spread of disease within the hatchery population. Under natural, low density conditions, most pathogens do not lead to a disease outbreak. When fish disease outbreaks do occur, they are often triggered by stressful hatchery rearing conditions, or by a deleterious change in the environment (Saunders 1991). Consequently, it is possible that the release of hatchery fish may lead to the loss of natural fish, if the hatchery fish are carrying a pathogen not carried by the natural fish, if that pathogen is transferred to the natural fish, and if the transfer of the pathogen leads to a disease outbreak.

Recent studies suggest that the incidence of some pathogens in naturally spawning populations may be higher than in hatchery populations (Elliott and Pascho 1994). The incidence of high ELISA titers for *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD), appears, in general, to be more prevalent to a statistically significant degree among natural-origin smolts of spring/summer Chinook salmon than hatchery smolts (Congleton et al. 1995; Elliot et al. 1997). For example, 95 percent and 68 percent of natural-origin and hatchery smolts, respectively, at Lower Granite Dam in 1995 had detectable levels of *R. salmoninarum* (Congleton et al. 1995). Although pathogens may cause a high rate of post-release mortality among hatchery fish, there is little evidence that hatchery-origin fish routinely infect naturally produced salmon and steelhead in the Pacific Northwest (Enhancement Planning Team 1986; Steward and Bjornn 1990).

Many of the disease concerns related to hatchery fish are based on old management styles that emphasized the release of large numbers of fish regardless of their health status. Since that time, the desire to reduce disease has instigated better husbandry, including critical decreases in fish numbers to reduce crowding and stress that affects the resistance of salmonids to disease (Salonius and Iwama 1993; Schreck et al. 1993). Along with decreased densities and improved animal husbandry, advances in fish health care and adherence to federal and interagency fish health policies have considerably decreased the possibility of disease transmission from hatchery fish to natural-origin fish.

State and federal fisheries agencies have established Fish Pathology labs and personnel who monitor and manage fish health in state, federal and tribal hatcheries. The success of hatchery programs as reflected in the production of quality smolts that will survive and reproduce depend on good fish health management. Fisheries managers, to meet hatchery fish quality goals and to address concerns of potential disease transmission from hatchery salmonids to naturally produced fish, have established a number of fish health policies in the Pacific Northwest Region. These policies established guidelines to ensure that fish health is monitored, sanitation practices are applied, and that hatchery fish are reared and released in healthy condition (PNFHPC 1989; IHOT 1995; WDFW 1996; WDFW and WWTIT 1998; USFWS 1995; USFWS 2004). Standard fish health monitoring under these policies include monthly and pre-release checks of propagated salmonid populations by a fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the populations. Specific reactive and proactive strategies for disease control and prevention are also included in the fish health policies. Fish mortality at the hatchery due to unknown cause(s) will trigger sampling for histopathological study. Incidence of viral pathogens in a salmonid broodstock is determined by sampling fish at spawning. Populations of particular concern may be sampled at the 100 percent level and may require segregation of eggs/progeny in early incubation or rearing. In some programs, progeny of high titer adults are culled to minimize disease incidence within the hatchery populations. Compliance with NPDES permit provisions at hatcheries also acts to minimize the likelihood for disease epizootics and water quality impacts that may lead to increased naturally produced fish susceptibility to disease outbreaks. Full compliance with the regional fish health policies minimizes the risk for fish disease transfer.

5.1.5.2.5 Competition/Density-Dependent Effects

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Adverse impacts of competition may result from direct interactions, whereby a hatchery-origin fish interferes with the accessibility to limited resources by naturally produced fish, or through indirect means, as in when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Specific hazards associated with adverse competitive impacts of hatchery salmonids on listed naturally produced salmonids may include food resource competition, competition for spawning sites, and redd superimposition. In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) categorized species combinations as to whether there is a high, low, or unknown risk that competition by hatchery fish will have a negative impact on productivity of naturally produced salmonids in freshwater areas (Table 5.1-2).

Table 5.1-2 Risk of hatchery salmonid species competition on naturally produced salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Naturally produced Species					
	Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	H	L	L	L	H	H
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	H	L	L	L	H	H
Chinook Salmon	H	L	L	L	H	H

Note: "H" = High risk; "L" = Low risk

Adult fish

It is apparent that salmonids have evolved a variety of strategies to partition available resources between species that are indigenous to a particular watershed. The addition of homing or straying adult hatchery-origin fish can perturb these mechanisms and impact the productivity of naturally produced stocks. For adult salmonids, impacts from hatchery/naturally produced fish competition in freshwater are assumed to be greatest in the spawning areas where competition for redd sites and redd superimposition may be concerns (USFWS 1994). Adult salmonids originating from hatcheries can also compete with naturally produced fish of the same species for mates, leading to an increased potential for outbreeding depression. Hatchery-origin adult salmonids may home to, or stray into, natural production areas during naturally produced fish spawning or egg incubation periods, posing an elevated competitive and behavioral modification risk. Returning or straying hatchery fish may compete for spawning gravel, displace naturally produced spawners from preferred, advantageous spawning areas, or adversely affect listed salmonid survival through redd superimposition. Superimposition of redds by similar-timed or later spawners, disturbs or removes previously deposited eggs from the gravel, and has been identified as an important source of natural salmon mortality in some areas (Bakkala 1970).

Recent studies suggest that hatchery-origin fish may be less effective in competing for spawning sites than naturally produced fish of the same species, possibly indicating the effects of domestication selection in the hatchery environment (Fleming and Gross 1993; Berejikian et al. 1997). These studies were based on comparisons of natural-origin salmonid adults and captive-brood origin hatchery fish. Hatchery-origin salmonid adults returning to spawn after a period of rearing in the wild may exhibit different competitive effectiveness levels.

The risk of straying by hatchery-produced species may be minimized through acclimation of the fish to their stream of origin, or desired stream of return. Acclimation of hatchery steelhead prior to release, however, does not reduce staying when compared to hatchery steelhead that are directly released into the target stream (Kenaston et al. 2001). Homing fidelity may be improved through the use of locally adapted stocks, and by rearing of the fish for an extended duration (e.g., eyed egg to smolt) in the "home" stream prior to release or transfer to a marine area net-pen site for further rearing.

The risk of redd superimposition can be minimized through high removal rates of the hatchery-origin fish, and by propagation and release of only indigenous species and stocks. Indigenous-origin hatchery adults that are not removed upon return may be assumed to still carry traits that foster temporal and spatial resource partitioning with natural-origin-spawning fish populations (see SIWG 1984). The risk of redd disturbance may therefore be minimal with escapement of indigenous-origin hatchery fish, if the home stream has the physical characteristics (e.g., stream flow, usable channel width) that will allow such partitioning at the time of spawning.

Juvenile Fish

For salmonids rearing in freshwater, food and space are the resources in demand, and thus are the focus of inter- and intra-specific competition (SIWG 1984). Newly released hatchery smolts may compete with naturally produced fish for food and space in areas where they interact during downstream migration. Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, of equal or greater size, and (if hatchery fish are released as non-migrants) the hatchery fish have taken up residency before naturally produced fry emerge from redds. Release of large numbers of hatchery pre-smolts in a small area is believed to have greater potential for competitive impacts because of the extended period of interaction between hatchery fish and natural fish. In particular, hatchery programs directed at fry and non-migrant fingerling releases will produce fish that compete for food and space with naturally produced salmonids for longer durations, if the hatchery fish are planted within, or disperse into, areas where naturally produced fish are present. A negative change in growth and condition of naturally produced fish through a change in their diet or feeding habits could occur following the release of hatchery salmonids. Any competitive impacts likely diminish as hatchery-produced fish disperse, but resource competition may continue to occur at some unknown, but lower level as natural-origin juvenile salmon and any commingled hatchery juveniles emigrate seaward.

Hatchery-origin smolts and sub-adults can also compete with naturally produced fish in estuarine and marine areas, leading to negative impacts on naturally produced fish in areas where preferred food is limiting. Steward and Bjornn (1990) concluded that hatchery fish kept in the hatchery for extended periods before release as smolts (e.g., yearling salmon) may have different food and habitat preferences than naturally produced fish, and that hatchery fish will be unlikely to out-compete naturally produced fish. Interactions with juvenile hatchery-origin salmonids may lead to behavioral changes in listed natural salmonids that are detrimental to productivity and survival.

Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Steward and Bjornn 1990; Hillman and Mullan 1989). In a review of the potential adverse impacts of hatchery releases on naturally produced salmonids, Steward and Bjornn (1990) indicated that it was indeterminate from the literature whether naturally produced parr face statistically significant risk of displacement by introduced hatchery fish, as a wide range of outcomes from hatchery-naturally produced fish interactions has been reported. The potential for negative impacts on the behavior, and hence survival, of naturally produced fish as a result of hatchery fish releases depends on the degree of spatial and temporal overlap in occurrence of hatchery and naturally produced fish. The relative size of affected naturally produced fish when compared to hatchery fish, as well as the abundance of hatchery fish encountered, also will determine the degree to which naturally produced fish are displaced (Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported displacement of juvenile naturally produced rainbow trout from discrete sections of streams by hatchery steelhead released into an upper Yakima River tributary, but no large scale displacements of trout were detected. Small scale displacements and agonistic interactions that were observed between hatchery steelhead and naturally produced trout resulted from the larger size of hatchery steelhead, which behaviorally dominated most contests. They noted that these behavioral interactions between hatchery-reared steelhead did not appear to have impacted the trout populations examined to a statistically significant degree, however, and that the population abundance of naturally produced salmonids did not appear to have been negatively affected by releases of hatchery steelhead.

Competition between hatchery and naturally produced salmonids in freshwater may only be at high risk for coho, Chinook salmon, steelhead, and sockeye, since pink and chum salmon do not rear for extended periods in freshwater (SIWG 1984). Studies indicate that hatchery coho salmon have the potential to adversely impact certain naturally produced salmonid species through competition. Information suggests that juvenile coho salmon are behaviorally dominant in agonistic encounters with juveniles of other stream-rearing salmonid species, including Chinook salmon, steelhead, and cutthroat trout (*O. clarki*), and with natural-origin coho salmon (Stein et al. 1972; Allee 1974; Swain and Riddell 1990; Taylor 1991). Dominant salmonids tend to capture the most energetically profitable stream positions (Fausch 1984; Metcalfe et al. 1986), providing them with a potential survival advantage over subordinate fish. However, where interspecific populations have evolved sympatrically, Chinook salmon and steelhead have evolved slight differences in habitat use patterns that minimize their interactions with coho salmon (Nilsson 1967; Lister and Genoe 1970; Taylor 1991). Along with the habitat differences exhibited by coho salmon and steelhead, they also show differences in foraging behavior. Peterson (1966) and Johnston (1967) reported that juvenile coho salmon are surface oriented and feed primarily on drifting and flying insects, while steelhead are bottom oriented and feed largely on benthic insects.

There is a hypothesis that large numbers of hatchery-produced smolts released into the Columbia River (including the Willamette) have adverse effects on naturally produced smolts in the migration corridor and ocean. High numbers of hatchery fish released throughout the Columbia Basin would have effects on listed Willamette fish when interacting in the lower Columbia, estuary, and ocean. This hypothesis assumes that there is a limitation on the capacity of the migration corridor and ocean and that there are adverse interactions between hatchery-produced and naturally produced smolts.

Interactions between hatchery juveniles and naturally produced fish in the migration corridor have been reduced by decreases in the number of hatchery fish released by Columbia River basin hatchery programs and by the mortality of hatchery fish after release. A production ceiling for all artificial propagation programs in the Columbia River basin was described in the Proposed Recovery Plan (NMFS 1995a) and in the 1999 artificial propagation Biological Opinion (NMFS 1999e). This production ceiling was approximately 197.4 million anadromous fish. Although releases occur throughout the year, approximately 80 percent occur from April through June. A significant portion of these releases do not survive to the Snake and Columbia River migration corridors. For example, the historical passage index of hatchery fish released into the Snake River Basin surviving to Lower Granite Dam shows a ratio of 0.23 for spring/summer Chinook salmon and 0.60 for steelhead; for hatchery releases in the Columbia River above McNary Dam the ratio is 0.185 for spring/summer Chinook salmon, 0.477 for sub-yearling Chinook salmon, 0.093 for steelhead, and 0.215 for coho salmon (FPC 1992). While the actual number of hatchery fish entering the Columbia River migration corridor is unknown, it is substantially less than the numbers released.

The speed of travel of upriver smolts also serves to reduce interaction and competition in the mainstem of the Columbia and the estuary. Bell (1991) gives rates of 13 miles/day (21 km/day) low flows and 23 miles/day (38 km/d) in moderate flows, as a general average for downstream migrants. Dawley et al. (1986) found rates of 1 to over 59 km/day in the estuary, depending on size, species and distance traveled, with the faster rates correlated with larger smolts from further upriver. In the free-flowing reaches of the Snake, Clearwater and Salmon, currents in excess of 10 km/hr are common during the spring freshet. Smolts could move in excess of 100 km/d just by holding in the thalweg, but the literature would indicate 40 to 50 km/day is a more likely average in moderate to high flows.

As occurs in rearing areas, habitat partitioning in the migration corridor among the species has evolved to reduce interspecific competition. Bell (1991) and Dawley et al. (1986) comment on differential habitat selection with steelhead choosing the thalweg and nearer to the surface, subyearling Chinook salmon being more likely to follow the shorelines and yearling Chinook salmon seeking greater depths.

Historically the bulk of the Columbia River adult returns were spring and summer Chinook salmon, coho salmon, sockeye salmon, and steelhead. Chapman (1986) calculated only 1.25 million adult fall Chinook salmon historically returned to the Columbia River in his high estimate, so over 80 percent of the smolts would have been spring migrating yearlings. Therefore, 160 to 320 million spring migrating yearling smolts (based on historical returns of approximately 10 million salmon and steelhead) would have passed through the estuary and entered the ocean in May and June each year, compared to less than 40 million under current conditions. In the past, when hatchery production in the basin reached nearly 200 million fish, over half of the production was fall Chinook salmon that produce sub-yearling, summer-migrating smolts, thus limiting potential to exceed the capacity of the migration corridor.

Habitat partitioning and speed of travel should function to reduce predation, competition and interspecies interactions. The reduced number of smolts in the corridor should also decrease the potential for detrimental interactions. However, the behavior of fish in the hydropower reservoirs and bottlenecks in collection and transportation systems may increase opportunities for interaction. Smolts may be disoriented by slack water and may be concentrated as the fish traveling 50 km/d in free-flowing rivers catch up to the fish traveling 10 km/d in the reservoirs. Smolts have been observed to concentrate in front of dams before they enter the collection system. In the collection and transportation system any habitat partitioning is eliminated, densities are increased and both inter- and intra-specific interactions are forced.

Considerable speculation, but little scientific information, is available concerning the overall impacts on listed salmon and steelhead from the combined number of hatchery fish in the Columbia River migration corridor. In a review of the literature, Steward and Bjornn (1990) indicated that some biologists consider density-dependent mortality during freshwater migration to be negligible; however, they also cited a steelhead study that indicated there may have been a density-dependent effect (Steward and Bjornn 1990). Hatchery and natural populations have similar ecological requirements and can potentially be competitors where critical resources are in short supply (Lower Granite Migration Study Steering Committee (LGMSC 1993).

The limited information available concerning impacts from changes in the historical carrying capacity to listed salmon is insufficient to determine definitive effects. It is for this reason that NMFS has called for a limitation of hatchery releases in the Columbia Basin. The effects of hatchery production on listed salmon and steelhead in the ocean would be speculative, since hatchery fish intermingle at the point of ocean entry with natural-origin and hatchery anadromous salmonids from many other regions. Witty et al. (1995) assessing the effects of Columbia River hatchery salmonid production on natural-origin fish stated:

> "We have surmised the ocean fish rearing conditions are dynamic. Years of limited food supply affect size of fish, and reduced size makes juveniles more subject to predation. Mass enhancement of fish populations through fish culture could cause density-dependant affects during years of low ocean productivity. However, we know of no studies which demonstrate, or even suggest, the magnitude of changes in numbers of smolts emigrating from the Columbia River Basin which might be associated with some level of change in survival rate of juveniles in the ocean. We can only assume that an increase in smolts might decrease ocean survival rate and a decrease might improve ocean survival rate."

However, the assumptions made by Witty et al. (1995) would apply only if the ocean were near carrying capacity. The current production from the Columbia River is lower than the number carried by the migration corridor and ocean in the fairly recent past.

The species of primary concern in the Columbia Basin are Chinook salmon, sockeye salmon and steelhead. There is no evidence in the literature to support the speculation that there is some compensatory mortality of Chinook salmon and steelhead in the ocean environment. There is evidence of density-dependent compensatory ocean survival in the cases of massive pink and chum salmon hatchery programs in Alaska, Russia and Japan (Pearcy 1992). There are currently two small chum salmon hatchery programs in the Lower Columbia River, the WDFW's Grays River program (including Chinook salmon River releases) and the Duncan Creek program below Bonneville Dam. These produce chum salmon at a level that is only a fraction of a percent of the numbers seen in Alaska, Russia and Japan. Pink salmon are functionally extinct in the Columbia River.

SIWG (1984) acknowledged that the risk of adverse competitive interactions in marine waters is difficult to assess, because of a lack of data collected at times when hatchery fish and naturally produced fish likely interact, and because competition depends on a variety of specific circumstances associated with hatchery-naturally produced fish interaction, including location, fish size, and food availability. In marine waters, the main limiting resource for naturally produced fish that could be affected through competition posed by hatchery-origin fish is food. The early marine life stage, when naturally produced fish have recently entered the estuary and populations are concentrated in a relatively small area, may create short term instances where food is in short supply, and growth and survival declines as a result (SIWG 1984). This period is viewed as of special concern regarding food resource competition posed by hatchery-origin chum salmon and pink salmon to naturally produced chum salmon and pink salmon populations (Cooney et al. 1978; Simenstad et al. 1980; Bax 1983). The degree to which food is limiting after the early marine portion of a naturally produced fish's life depends upon the density of prey species. This does not discount limitations posed on naturally produced fish in more seaward areas as a result of competition by hatchery-origin fish, as data are available that suggests that marine survival rates for salmon are density dependent, and thus possibly a reflection of the amount of food available (SIWG 1984).

The risk of adverse competitive interactions can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990).
- Operating hatcheries such that hatchery fish are reared to sufficient size that smoltification occurs within nearly the entire population (Bugert et al. 1992).
- Rearing juvenile hatchery fish on parent river water, or acclimating them for several weeks to parent river water, will contribute to the smoltification process and reduced retention time in the streams.
- Releasing hatchery smolts after the major seaward emigration period for naturally produced salmonid populations to minimize the risk of interaction that may led to competition.
- Releasing hatchery smolts in lower river areas, below upstream areas used for stream-rearing young-of-the-year naturally produced salmonid fry.

5.1.5.2.6 Predation

Risks to naturally produced salmonids attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) can result from hatchery salmonid releases in freshwater and estuarine areas. Hatchery-origin fish may prey upon juvenile naturally produced salmonids at several stages of their life history. Newly released hatchery smolts have the potential to prey on naturally produced fry and fingerlings that are encountered in freshwater during downstream migration, or if the hatchery fish residualize prior to migrating. Hatchery-origin smolts, sub-adults, and adults may also prey on naturally produced fish of susceptible sizes and life stages (smolt through sub-adult) in estuarine and marine areas where they commingle. Hatchery salmonids planted as non-migrant fry or fingerlings, and progeny of naturally spawning hatchery fish also have the potential to prey upon natural-origin salmonids in freshwater and marine areas where they co-occur. In general, naturally produced salmonid populations will be most vulnerable to predation when naturally produced populations are depressed and predator abundance is high, in small streams, where migration distances are long, and when environmental conditions favor high visibility. SIWG (1984) categorized species combinations as to whether there is a high, low, or unknown risk that direct predation by hatchery fish will have a negative impact on productivity of naturally produced salmonids (Table 5.2-3).

SIWG (1984) rated most risks associated with predation as unknown, because, although there is a high potential that hatchery and naturally produced species interact, due to a high probability of spatial and temporal overlap, there was relatively little literature documentation of predation interactions in either freshwater or marine areas. Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (SIWG 1984). Some reports suggest that hatchery fish can prey on fish that are ½ their length (HSRG 2004; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prefer smaller fish and are generally thought to prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin co-specifics reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

Table 5.2-3 Risk of hatchery salmonid species predation on naturally produced salmonid species in freshwater areas (SIWG 1984).

Hatchery Species	Naturally produced Species					
	Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Note: "H" = High risk; "L" = Low risk; and "U" = Unknown risk of a significant impact occurring.

Due to their location, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation by hatchery released fish. Their vulnerability is believed to be greatest as they emerge and decreases somewhat as they move into shallow, shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may minimize the degree of predation on salmonid fry (USFWS 1994).

Although considered as of "unknown" risk by SIWG (1984), data from hatchery salmonid migration studies on the Lewis River, Washington, Hawkins and Tipping (1998) provide evidence of hatchery coho salmon yearling predation on salmonid fry in freshwater. The WDFW Lewis River study indicated low levels of hatchery steelhead smolt predation on salmonids. In a total sample of 153 out-migrating hatchery-origin steelhead smolts captured through seining in the Lewis River between April and June 24, 12 fish (7.8 percent) were observed to have consumed juvenile salmonids (Hawkins and Tipping 1998). The juvenile salmonids contained in the steelhead stomachs appeared to be Chinook salmon fry. Sampling through this study indicated that no emergent natural-origin steelhead or trout fry (30-33 mm fl) were present during the first two months of sampling. Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. A small number (11) of spring Chinook salmon smolts were sampled and remains of 10 salmonids were found (includes multiple observations of remains from some smolts). Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat predominately) than their hatchery counterparts. Steward and Bjornn (1990) referenced a report from California that estimated, through indirect calculations, rather than actual field sampling methods, the potential for substantial predation impacts by hatchery yearling Chinook salmon on naturally produced Chinook salmon and steelhead fry. They also reference a study in British Columbia that reported no evidence of predation by hatchery Chinook salmon smolts on emigrating naturally produced Chinook salmon fry in the Nicola River. In addition, young coho salmon in some British Columbia streams averaged two to four chum salmon fry per stomach sampled (Bakkala 1970).

Predation by hatchery fish on natural-origin smolts or sub-adults is less likely to occur than predation on fry. Coho salmon and Chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). During early marine life, predation on naturally produced Chinook salmon, coho, and steelhead will likely be highest in situations where large, yearling-sized hatchery fish encounter sub-yearling fish or fry (SIWG 1984). Juanes (1994), in a survey of studies examining prey size selection of piscivorus fishes, showed a consistent pattern of selection for small-sized prey. Hargreaves and LeBrasseur (1986) reported that coho salmon smolts ranging in size from 100-120 mm fl selected for smaller chum salmon fry (sizes selected 43-52 mm fl) from an available chum salmon fry population including larger fish (available size range 43-63 mm fl). Ruggerone (1989, 1992) also found that coho salmon smolts (size range 70-150 mm fl) selected for the smallest sockeye fry (28-34 mm fl) within an available prey population that included larger fish (28-44 mm fl). However, extensive stomach content analyses of coho salmon smolts collected through several studies in marine waters of Puget Sound, Washington, do not substantiate any indication of significant predation upon juvenile salmonids (Simenstad and Kinney 1978). Similarly, Hood Canal, Nisqually Reach, and north Puget Sound data show little or no evidence of predation on juvenile salmonids by juvenile and immature Chinook salmon (Simenstad and Kinney 1978). In a recent literature review of Chinook salmon food habits and feeding ecology in Pacific Northwest marine waters, Buckley (1999) concluded that cannibalism and intra-generic predation by Chinook salmon are rare events. Likely reasons for apparent low predation rates on salmon juveniles, including Chinook salmon, by larger Chinook salmon and other marine predators suggested by Cardwell and Fresh (1979) include:

- The rapid growth in fry, resulting in the increased ability to elude predators and becoming accessible to a smaller proportion of predators due to size alone.
- The rapid dispersal of fry, making them present in lower densities relative to other fish and invertebrate prey.
- The learning or selection for some predator avoidance.

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating naturally produced fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter naturally produced salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (Hillman and Mullan 1989; USFWS 1994). Hatchery fish released into naturally produced fish production areas, or into migration areas during naturally produced fish emigration periods, may therefore pose an elevated, indirect predation risk to commingled listed fish. Alternatively, a mass of hatchery fish migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring listed naturally produced fish.

Hatchery impacts from predation can be minimized by:

- Releasing actively migrating smolts through volitional release practices.
- Insuring that a high proportion of the population has smolted prior to release using minimum coefficient of variation population size limits. Smolts tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Delaying hatchery fish releases until the major seaward emigration period for naturally produced salmonid populations has been completed can minimize the risk of interaction that may led to predation.
- Releasing hatchery smolts in lower river areas, below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism (see discussion below).

5.1.5.2.7 Residualism

Artificially propagated smolts are released into rivers and streams with the anticipation that they will migrate to the ocean. In many cases, some portion of the hatchery-produced juveniles will “residualize,” or become residents of the receiving water for an extended period of a year or more. The general effects of hatchery-produced fish on natural fish, as described by Steward and Bjornn (1990) may be exacerbated if a substantial portion of the hatchery-produced juvenile salmonids residualize.

As discussed in sections 4.1.5 and 4.1.6, above, particular concern has been identified when hatchery steelhead, released into spawning and nursery areas, fail to migrate (residualize), and potentially prey upon or compete with listed salmon and steelhead juveniles. Steelhead residualism has been found to vary greatly, but is thought to typically average between 5 percent and 10 percent of the number of fish released (USFWS 1994). Releasing hatchery steelhead smolts that are prepared to migrate and timing the release to occur during high flow conditions may minimize impacts on listed fish from hatchery steelhead programs.

Coho salmon, in most situations, do not have the same potential to residualize as steelhead, but approximately 6 percent of the coho salmon planted as parr residualized in the receiving stream in the Clearwater River drainage for a year after release (Johnson and Sprague 1996). Coho salmon parr stocked in 1995, were observed two years after release in snorkel surveys and screw traps (BIA 1998) and about 2,000 age two coho salmon smolts were counted at Snake River mainstem dams (BIA 1998). So far there does not appear to be any residualism of coho salmon smolts released into the Yakima and Methow Rivers.

Ocean-type Chinook salmon, like the fall Chinook salmon of the Snake River and mid-Columbia generally begin migration towards salt water soon after emergence, however some may spend up to one year before undertaking the smolt migration (Healey 1991). In the Snake River, Connor et al. (1992) report a small percentage of hatchery-produced fall Chinook salmon smolts spend more than a year as residents in the Snake River before smolting. Although most stream-type Chinook salmon juveniles become smolts in the spring one year after emergence, some may spend a second year in fresh water, particularly slower- growing individuals. This effect may be related to cooler water temperatures in more northern or higher elevation waters (Healey 1991).

The variability in life history exhibited by naturally produced anadromous salmonids probably has some adaptive and survival advantages. By allowing slow-growing fish extra time in freshwater this strategy may ensure smolts that are large enough to improve migration survival. That not all spawners are the same age allows transfer of genetic material between brood years of a population and protects against loss of an entire spawning year to a single natural catastrophe. Adaptability to cooler water or less productive water by extending freshwater residency may allow anadromous fish to occupy a greater variety of habitats. The current conventional wisdom on hatchery management would support the standardization of life history and the rearing protocols which produce smolts on a single, uniform, schedule, but this practice may be intentionally selecting away from the genetic heritage of the fish. For supplementation hatchery programs, and as artificial propagation practices include more natural rearing environments, hatchery managers may have to accommodate variable life histories in their production protocols.

In the case of artificial propagation programs for unlisted steelhead, particularly the programs that rear composite, domesticated and out-of-basin stocks, hatchery managers should continue to develop rearing and release protocols that reduce residualism and improve the smolting response, including acclimation, volitional release and growth schedules that produce healthy smolts that are of the proper size and stage of development at the appropriate time to initiate the smolt migration.

Steelhead residuals normally remain near their release point (Whitesel et al. 1993; Jonasson et al. 1994; 1995 and 1996; Cannamela 1992). Partridge (1985) noted that most residual steelhead were within about 8 km of the upper Salmon River release site. Schuck et al. (1998) reported steelhead residuals were found about 20 km below and 10 km above release sites in the Tucannon River, Washington. Steelhead residual densities were highest within 8 km of release sites and decreased quickly above and below these sites in the Grande Ronde and Imnaha Rivers in Oregon (Whitesel et al. 1993).

The number of residual steelhead appears to decline steadily throughout the summer in most Snake River basin release areas. This may be due to harvest, other mortality, and outmigration. Viola and Schuck (1991) noted that residual populations in the Tucannon River of Washington declined at a rate of about 50 percent per month from June to October (declining from 4.3 to 0.8 percent of the total released). Whitesel et al. (1993) found residual steelhead up to twelve months after release, however, densities declined rapidly over time.

Acclimation ponds and volitional release strategies are currently the subject of active research in the Columbia River Basin. It is unclear at this time whether or not acclimating and volitionally releasing steelhead smolts can substantially reduce the proportion of residualized steelhead in all cases. WDFW appears to be able to substantially reduce the number of residualized steelhead by using a combination of acclimation, volitional release strategies, and active pond management whereby remaining steelhead are not released when sampling indicates the majority of remaining fish in a pond are males. This action is taken because preliminary WDFW research indicates that the majority of residualized steelhead are males. The ODFW monitoring has not confirmed WDFW results (USFWS 1994). The ODFW saw no reduction in steelhead residualism rates in 1993 from acclimated fish in comparison to direct stream releases; however, they did not employ active pond management strategies (USFWS 1994). Lindsay et al. (2001) found no difference in the number of residualized hatchery steelhead observed at the release site between acclimated and direct stream release groups. Lindsay et al. (2001) observed that residualism was related more to the size of the fish than to whether they were acclimated.

In the 1995-98 Biological Opinion for Hatchery Operations in the Columbia River Basin (NMFS 1995b), NMFS recommended that hatchery steelhead smolts be released at sizes between 170 and 220 mm total length (TL), approximately 163-212 mm fork length (FL), based primarily on the work of two IDFG researchers, Cannamela (1992, 1993) and Partridge (1985). The maximum size recommendation was based on reports of higher residualism among steelhead over 240 mm TL and higher predation rates by residual steelhead over 250 mm TL. Analysis by IDFG suggests that the 220 mm maximum size is less than the ideal size to release smolts (Rhine et al. 1997). In several tests, Rhine reports that residualized steelhead are significantly smaller than smolts. Of those steelhead smolts carrying PIT tags, 52.1 percent of fish released at 163-211 mm, 66 percent of steelhead 212-250 mm TL, and 83.3 percent of steelhead greater than 250 mm TL were detected at downstream dams. Bigelow (1997) reported similar results in PIT tagged steelhead smolts released from Dworshak Hatchery. Over 70 percent of steelhead less than 180 mm TL were not detected while approximately 85 percent of smolts over 180 mm TL were detected at the downstream sites.

This information suggests that release of juvenile steelhead less than 180 mm TL will contribute to residualism and the ideal release size may be larger than 220 mm TL. However, concern for both residualism and predation by very large smolts (over 250 mm TL) is still valid. Jonasson et al. (1996) reported predation on naturally produced juvenile steelhead by residual hatchery steelhead as small as 189 mm TL, but in general the larger residual fish tended more toward predation. Overall, Jonasson et al. (1996) reports a low level of piscivory by residuals less than 230-250 mm TL.

Based on this information the recommended steelhead smolt size range should be 180 mm to 250 mm TL. Further, if predation increases as size of fish released from hatcheries increases, then hatchery managers should avoid release of larger smolts in waters that support rearing fry of listed species. Hatchery managers should continue to evaluate the impacts of size at release on predation and residualism along with other measures to increase smolting success.

Smolts that residualize for some period of time not only pose a potential threat to naturally produced salmonids, they have a lower probability of returning as adults and fulfilling the intended purpose of recovery, fishery enhancement, or mitigation. Healthy hatchery-produced smolts that migrate to the ocean soon after release have a good chance to return as adults, while those that select an extended stream residence often do not survive (Steward and Bjornn 1990). If a high percentage of hatchery-produced smolts successfully return as adults, less production is required to meet recovery, mitigation or treaty trust responsibilities.

Residualism is primarily a concern for releases of hatchery steelhead and not spring Chinook salmon, fall Chinook salmon, and coho salmon. However, a small portion of coho salmon when released as parr have been observed to have residualized (Dunnigan 1999).

5.1.5.2.8 Fisheries

Fisheries managed for, or directed at, the harvest of hatchery-origin fish have been identified as one of the primary factors leading to the decline of many naturally produced salmonid stocks (Flagg et al. 1995; Myers et al. 1998). Depending on the characteristics of a fishery regime, the commercial and recreational pursuit of hatchery fish can lead to the harvest of naturally produced fish in excess of levels compatible with their survival and recovery (NRC 1996). Listed salmon and steelhead may be intercepted in mixed stock fisheries targeting predominately returning hatchery fish or healthy natural stocks (Mundy 1997). Fisheries can be managed for the aggregate return of hatchery and naturally produced fish, which can lead to higher than expected harvest of naturally produced stocks.

In recent years harvest management has undergone substantial reforms and many of the past problems have been addressed. Principles of weak stock management are now the prevailing paradigm. Listed salmon and steelhead are no longer the target of fisheries. Mixed stock fisheries are managed based on the needs of natural-origin stocks. In many areas fisheries have been closed to protect natural-origin populations (e.g., before 2005 upper Salmon River spring Chinook salmon fisheries were closed to non-treaty recreational fishing for more than 20 years). Managers also account, where possible, for total harvest mortality across all fisheries. The focus is now correctly on conservation and secondarily on providing harvest opportunity where possible directed at harvestable hatchery and natural-origin stocks. For an in depth review of harvest management actions affecting Columbia River salmon and steelhead see chapter 3 of the LCFRB's recovery plan (LCFRB 2004). These management changes have resulted in harvest no longer being considered one of the top five limiting factors for almost all of the listed species (see Table 14).

Rutter (1997) observed that the effects on listed stocks from harvesting hatchery-produced fish can be reduced by certain management actions:

- Externally marking hatchery fish so that they can be differentiated from unmarked, natural fish.
- Conducting fisheries that can selectively harvest only hatchery-produced fish with naturally produced fish being released.
- Managing fisheries for the cumulative harvest rate from all fisheries to ensure impacts are not higher than expected (Mundy 1997).
- Ensuring that harvest rates are not increased because of a large return of hatchery fish, fisheries can be managed based on the abundance and status of naturally produced fish.

- Releasing hatchery fish from terminal areas so that returning adults can be harvested with little or no interception of naturally produced fish. Fisheries can occur near acclimation sites or in other areas where released hatchery fish have a tendency to concentrate, which reduces the catch of naturally produced fish.
- Reducing or eliminating the number of fish released from hatcheries if fisheries targeting hatchery fish cannot be managed compatible with the survival and recovery of listed fish.

Catchable Trout Fisheries

Many hatchery programs produce rainbow trout (and other trout species) for recreational fisheries to meet mitigation obligations for lost recreational harvest opportunities. These programs have had an adverse effect on anadromous steelhead juveniles because fisheries targeting the trout typically intercept, catch, handle, and sometimes kill juvenile salmon and steelhead.

5.1.5.2.9 Masking

Returning adult hatchery fish can stray into natural spawning areas confounding the ability to determine the annual abundance of naturally produced fish. This can lead to an over-estimation of the actual abundance and productivity of the natural population, and to an inability to assess the health and production potential of the critical habitat for that population. This latter factor exists because the hatchery fish are not subject to the same spawning and early life history productivity limits experienced by the natural population in the natural freshwater environment. The abundance and productivity of the naturally produced fish and the health of the habitat that sustains them, is therefore “masked” by the continued infusion of hatchery-produced fish.

Masking of natural fish status by naturally spawning hatchery fish produced for harvest augmentation purposes was one basis for the recommended listing of the Puget Sound Chinook salmon ESU as “threatened” under the ESA (Myers et al. 1998). Annual spawning ground censuses of fall Chinook salmon populations had historically aggregated naturally spawning hatchery and naturally produced fish. When an identifying mark was applied to a proportion of the hatchery fish, efforts were made to subtract out hatchery fish from escapement estimates through expanded mark recovery estimates. In many instances, however, the release of unmarked hatchery fall Chinook salmon groups, predominately of a single stock, led to the situation where salmon spawning escapement abundances were artificially sustained, and the actual annual abundances of the indigenous naturally produced fall Chinook salmon populations in some watersheds were over-estimated or unknown.

Attempts to identify and remedy anthropogenic factors adversely affecting fish habitat may be impeded through masking of natural fish status. For example, instability and degradation of spawning gravel areas through flooding during critical spawning or egg incubation periods may not be recognized as a limiting factor to natural production if annual spawning ground censuses are subsidized by returning adults from annual hatchery releases. If the vast majority of the adult fish observed were of direct hatchery origin, the poor natural productivity status of the spawning areas will not be evident without additional, expansive monitoring efforts.

Resolution of the masking issue can be achieved by:

- Providing an effective means to easily differentiate hatchery fish from natural-origin fish on the spawning grounds. One avenue available is a readily visible external mark applied to hatchery fish prior to release combined with an effective spawning ground census program designed to derive separate estimates of hatchery and natural fish. Mass marking of hatchery fish using an internal mark (e.g., otolith banding) may also be used to differentiate hatchery from natural-origin fish on the spawning grounds, if a statistically valid adult sampling design to collect and analyze mark recovery data is also implemented.
- Plant or release fish only in areas where "masking" is not an issue but still mark enough fish to monitor straying.
- Removing hatchery fish through selective fisheries or at weirs and dams.
- Imprinting hatchery fish to return to lower river or tributary areas not used by natural fish in a watershed.
- Reducing or limiting hatchery fish release numbers leading to decreased adult hatchery fish returns may also reduce masking effects.

5.1.5.2.10 Nutrient Cycling

The flow of energy and biomass from productive marine environments to relatively unproductive terrestrial environments supports high productivity in the ecotone where the two ecosystems meet (Polis and Hurd 1996). Anadromous salmon are a major vector for transporting marine nutrients across ecosystem boundaries (i.e. from marine to freshwater and terrestrial ecosystems). Because of the long migrations of some stocks of Pacific salmon, the link between marine and terrestrial production may be extended hundreds of miles inland. Nutrients and biomass extracted from the milt, eggs, and decomposing carcasses, of spawning salmon stimulate growth and restore the nutrients of aquatic ecosystems. Nutrients originating from salmon carcasses are also important to riparian plant growth. Direct consumption of carcasses and secondary consumption of plants and small animals that are supported by carcasses is an important source of nutrition for terrestrial wildlife (Cederholm et al. 1999).

Current escapements of naturally produced and naturally spawning hatchery-produced anadromous salmonids in the Columbia Basin are estimated at about 7 percent of the historical biomass (Cederholm et al. 1999). Throughout the Pacific Northwest, the delivery of organic nitrogen and phosphorus to the spawning and rearing streams for anadromous salmonids has been estimated at 5 to 7 percent of the historical amount (Gresh et al. 2000). Cederholm et al. (1999) calculate the historical spawning escapement at 45,150 mt (metric ton) of biomass annually added to the aquatic ecosystems of the Columbia compared to 3,400 mt annually with current spawning escapements.

Artificial propagation programs in the basin add substantial amounts of fish biomass to the freshwater ecosystem. The annual hatchery production cap of nearly 200 million smolts, at 25 g/smolt average weight, adds about 5,000 mt of biomass to the Columbia Basin. Returning adults from artificial propagation programs have totaled 800,000 to 1,000,000 in recent years (ODFW and WDFW 1998). At the average weight of 6.75 kg used by Cederholm et al. (1999), 5,400 to 6,750 mt of fish biomass is potentially returned to the Columbia River annually due to artificial propagation programs. Of course, most of the hatchery smolt production is expected to leave freshwater and migrate to the marine ecosystem, but undoubtedly some is retained in freshwater and terrestrial ecosystems as post-release mortalities and consumption by predators such as bull trout, ospreys and otters. Much of the adult return from hatchery production may be removed from the ecosystem by selective fisheries or taken at hatchery weirs and traps.

However, the potential to utilize the marine-derived nutrients that are imported to freshwater ecosystems in the carcasses of hatchery returns may be of value for stimulating ecosystem recovery. Experiments have shown that carcasses of hatchery-produced salmon can be an important source of nutrients for juvenile salmon rearing in streams (Bilby et al. 1998). Hatchery carcasses may also replace some of the nutrient deficit in riparian plant and terrestrial wildlife communities where naturally produced spawners are lacking. The contribution of artificial propagation programs has the potential to exceed the contribution of naturally produced fish in replenishing the nutrient capital of aquatic ecosystems in the short term, but should not be regarded as a long term solution to replacing the nutrient subsidy provided by naturally produced salmon.

5.1.5.2.11 Monitoring & Evaluation

Monitoring and Evaluation programs are necessary to determine the performance of artificial propagation programs. The Artificial Production Review (NPPC 1999) listed four criteria for evaluating both augmentation and mitigation programs:

1. Has the hatchery achieved its objectives?
2. Has the hatchery incurred costs to natural production?
3. Are there genetic impacts associated with the hatchery production?
4. Is the benefit greater than the cost?

Historically, hatchery performance was determined solely on the hatchery's ability to release fish (NPPC 1999), this was further expanded to include hatchery contribution to fisheries (Wallis 1964; Wahle and Vreeland 1978; Vreeland 1989). Past program-wide reviews of artificial propagation programs in the Northwest have indicated that monitoring and evaluation has not been adequate to determine if the hatchery objectives are being met (ISG 1996; NRC 1996; NFHRP 1994). The lack of adequate monitoring and evaluation has resulted in the loss of information that could have been used to adaptively manage the hatchery programs (NRC 1996).

Under the ESA, monitoring and evaluation programs for artificial production are not only necessary for adaptive management purposes but are required to ensure that artificial propagation activities do not limit the recovery of listed populations. Monitoring and evaluation of artificial propagation activities are necessary to determine if management actions are adequate to reduce or minimize the impacts from the general effects discussed previously, and to determine if the hatchery is meeting its performance goals. Monitoring and evaluation activities will occur within the hatchery facilities as well as in the natural production areas. Monitoring and evaluation within the hatchery can include measurements to evaluate hatchery production (i.e., survival, nutrition, size at age, condition, disease prevention, genetic makeup, total released, percent smolted, etc.).

Monitoring and evaluation to determine impacts on listed fish from artificial propagation programs can itself have potential adverse impacts on listed fish in the hatchery though injuries incurred during sampling and marking. Sampling within the hatchery can include direct mortalities (e.g., genetic analysis, disease pathology, smolt condition) and indirect take (e.g. sorting, marking, transfers). Marking of hatchery fish prior to release is required for all programs to monitor and evaluate hatchery effects (positive and negative). Marking is necessary to evaluate a number of objectives including selecting broodstock, determining hatchery stray rates and hatchery contributions to fisheries, and for the implementation of selective fisheries that target hatchery fish.

For hatchery supplementation programs, the goal is to promote the viability of natural-origin populations as the factors limiting viability are reduced by using hatchery fish to increase the number of natural spawners. Monitoring and evaluation for this goal requires the sampling of naturally produced adults and juveniles in natural production areas. In the Columbia River Basin, many of these naturally produced populations are listed under the ESA.

Monitoring and evaluating fish and fish assemblages in the natural environment is necessary to determine any positive or negative effects the artificial production program is having on the natural population. Genetic and life-history data may need to be collected from the natural population to determine if the hatchery population has diverged from the natural population and if the natural population has been altered by the incorporation of hatchery fish into the spawning population. Sampling methods can include the use of weirs, electro-fishing, rotary screw traps, seines, hand nets, spawning ground surveys, snorkeling, radio tagging, and carcass recovery. Each sampling method can be used to collect a variety of information. Sample methods, like tagging methods, can adversely impact listed fish, both those targeted for data collection and those taken incidentally to the data collection.

NMFS has developed some general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000c) which have been incorporated as terms and conditions into section 10 and section 7 permits for research and enhancement activities (NMFS 2000c). Though necessary to monitor and evaluate impacts on listed populations from artificial propagation programs, monitoring and evaluation programs should be designed and coordinated with other plans to maximize the data collection while minimizing take of listed fish.

5.1.6 Water Marketing

Under baseline conditions, there are a total of 205 long-term water service contracts for the diversion of water released from storage at Project dams in the Willamette basin (Table 2-12). This water is used exclusively for irrigation, with use primarily occurring during the summer (July and August).

There are 62 pending applications that, if approved, would divert an additional 30,200 acre-feet of stored water. Upon execution of these contracts, the Reclamation water contract program will include 267 active long-term contracts for annual irrigation with up to 80,431 acre-feet of stored water; approximately 5% of the active conservation storage space available in project reservoirs.[1]

[1] The 205 contracts presently in force cover approximately 3% of the available conservation storage space.

Under the Proposed Action, Reclamation would cap its water marketing program at 95,000 acre-feet for the term of this Opinion. Taking both existing contracts and pending contract applications into account, 14,569 acre-feet would remain available to meet future irrigation demands under the duration of the Opinion. In the event that future irrigation demand exceeded the 95,000 acre-feet, Reclamation and the USACE would reevaluate the availability of water from conservation storage for the water marketing program and would consult with the Services prior to marketing additional water.

Because USACE intends to serve these contracts with water released from storage to meet maintain tributary and mainstem minimum flows, water diverted under these water service contracts is likely to reduce the fish habitat value of the affected streams from the point of diversion downstream. That is, under the Proposed Action more water would be removed from the Willamette River and its tributaries during the irrigation season without any additional water being released from USACE's reservoirs.

Such flow reductions may reduce the habitat area, or habitat quality, available to salmon and steelhead during the late summer. Such flow reductions could exacerbate local fish passage problems but are most likely to affect juvenile Chinook and steelhead that rear in the affected stream reaches. Reducing streamflow would also reduce the mass of water subject to atmospheric heating, causing water temperatures to increase, which could adversely affect rearing juveniles and holding adults. Water development and fish use vary among the tributary basins and these effects are considered for each occupied tributary in the sections below.

5.1.7 Climate Change Considerations

As described in Section 4.1, ongoing climate change has the potential to adversely affect habitat conditions for salmonids throughout the Columbia basin, including the Willamette basin. The following sections describe how the Proposed Action would respond to the ISAB's recommendations to proactively address these effects.

5.1.7.1 ISAB Recommendations

In addition to describing the potential effects of climate change in the Columbia basin (Section 4.1 of this document), the ISAB provides a series of recommendations to proactively address these anticipated effects (ISAB 2007). This section presents ISAB's recommendations and identifies those elements of the Proposed Action that would respond to them.

Planning Actions

1. Assessing potential climate change impacts in each subbasin and developing a strategy to address these concerns should be a requirement in subbasin plan updates. Providing technical assistance to planners in addressing climate change may help ensure that this issue is addressed thoroughly and consistently in the subbasin plans.
2. Tools and climate change projections that will aid planners in assessing subbasin impacts of climate change are becoming more available. Of particular interest for the Columbia Basin is an online climate change streamflow scenario tool that is designed to evaluate vulnerability to climate change for watersheds in the Columbia Basin

(www.cses.washington.edu/cig/fpt/ccstreamflowtool/sft.shtml). Models like this one can be used by planners to identify sensitivities to climate change and develop restoration activities to address these issues.

3. Locations that are likely to be sensitive to climate change and have high ecological value would be appropriate places to establish reserves through purchase of land or conservation easements. Landscape-scale considerations will be critical in choice of reserve sites, as habitat fragmentation and changes of habitat will influence the ability of such reserves to support particular biota in the future. These types of efforts are already supported by the Fish and Wildlife Program, but actions have not yet been targeted to address climate change concerns.

Tributary Habitat

1. Minimize temperature increases in tributaries by implementing measures to retain shade along stream channels and augment summer flow
   - Protect or restore riparian buffers, particularly in headwater tributaries that function as thermal refugia
   - Remove barriers to fish passage into thermal refugia
2. Manage water withdrawals to maintain as high a summer flow as possible to help alleviate both elevated temperatures and low stream flows during summer and autumn
   - Buy or lease water rights
   - Increase efficiency of diversions
3. Protect and restore wetlands, floodplains, or other landscape features that store water to provide some mitigation for declining summer flow
   - Identify cool-water refugia (watersheds with extensive groundwater reservoirs)
   - Protect these groundwater systems and restore them where possible
   - May include tributaries functioning as cool-water refugia along the mainstem Columbia where migrating adults congregate
   - Maintain hydrological connectivity from headwaters to sea

Mainstem and Estuary Habitat

1. Remove dikes to open backwater, slough, and other off-channel habitat to increase flow through these areas and encourage increased hyporheic flow to cool temperatures and create thermal refugia

Mainstem Hydropower

1. Augment flow from cool/cold water storage reservoirs to reduce water temperatures or create cool water refugia in mainstem reservoirs and the estuary
   - May require increasing storage reservoirs, but must be cautious with this strategy
   - Seasonal flow strategy

2. Use of removable spillway weirs (RSW) to move fish quickly through warm forebays and past predators in the forebays.
   - Target to juvenile fall Chinook salmon
3. Reduce water temperatures in adult fish ladders
   - Use water drawn from lower cool strata of forebay
   - Cover ladders to provide shade
4. Transportation
   - Develop temperature criteria for initiating full transportation of juvenile fall Chinook salmon
   - Explore the possibility of transporting adults through the lower Snake River when temperatures reach near-lethal limits in later summer
   - Control transportation or in-river migration of juveniles so that ocean entry coincides with favorable environmental conditions
5. Reduce predation by introduced piscivorous species (e.g., smallmouth bass, walleye, and channel fish) in mainstem reservoirs and the estuary

Harvest

1. Harvest managers need to adopt near-and long-term assessments that consider changing climate in setting annual quotas and harvest limits
   - Reduce harvest during favorable climate conditions to allow stocks that are consistently below sustainable levels during poor phase ocean conditions to recover their numbers and recolonize areas of freshwater habitat
   - Use stock identification to target hatchery stocks or robust natural-origin stocks, especially when ocean conditions are not favorable
   - Control juvenile migration to ensure that ocean entry coincides with favorable ocean conditions[2]

5.1.7.2 Measures in the Proposed Action Responding to the ISAB Recommendations

The Proposed Action includes measures designed to restore a more natural thermal regime to waters downstream from the dams to benefit salmonid habitat. During the period of the Opinion the Action Agencies will continue to implement and study the long term effects of the current water temperature control system at Cougar Dam. In the Proposed Action, the Action Agencies propose continued operation of the Cougar Water Temperature Control Facility and to conduct a

[2] If the ocean condition becomes less productive, density dependence will be intensified, resulting in increased competition among species and stocks in the ocean. This may result in lower growth and survival rates for wild salmon in the ocean. Reduction in hatchery release during poor ocean conditions may enhance survival of wild stocks, but more research is necessary (ISAB 2007).

program of RM&E to evaluate its biological effectiveness. However, they do not propose to implement temperature control operations or to build facilities in other subbasins.

The Proposed Action includes minimum and maximum flow objectives for reaches below the Project dams. The Action Agencies propose to use water stored in Project reservoirs to meet these objectives in a manner that addresses changes in seasonal streamflow patterns related to climate change. The Action Agencies will conduct studies to ensure that these requirements are adequate and will operate to meet revised objectives, if needed.

The Action Agencies will implement habitat improvement projects including those that will enhance habitat conditions on the mainstem Willamette, by improving stream shading, providing floodplain and hydraulic connectivity to the Delta Ponds near Eugene, and using large wood taken from Project reservoirs to create deep, cool water pools in downstream reaches. These actions address the ISAB's recommendations by increasing habitat connectivity and the availability of thermal refugia.

Section 5.2
Middle Fork Willamette Effects

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5.2 MIDDLE FORK WILLAMETTE RIVER SUBBASIN: EFFECTS OF THE WILLAMETTE PROJECT PROPOSED ACTION ON UWR CHINOOK SALMON & CRITICAL HABITAT

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- The Proposed Action (continued operation of the dams, maintenance of revetments, and hatchery operations) would allow existing adverse conditions for Middle Fork Willamette Chinook salmon to persist:
  - Fish would continue to have limited upstream and downstream passage at Project dams, preventing safe access to historical habitat and limiting spatial distribution (VSP parameter) and access to spawning and rearing habitat (PCEs of critical habitat).
  - Habitat downstream of Project dams would continue to be degraded by lack of sediment and large wood transport, altered flow regimes, and altered water quality below the dams, resulting in continued decline in abundance and productivity.
- As a result, the Middle Fork Willamette River Chinook salmon population already at very low levels, would continue to decline. Critical habitat would be further degraded.

CHINOOK POPULATION & CRITICAL HABITAT

Historically, the Middle Fork Willamette Chinook salmon population may have been the largest of all populations in the UWR Chinook salmon ESU. McElhany et al. (2007) have suggested that the Middle Fork subbasin once likely produced tens of thousands of adult spring Chinook. However, recent returns of naturally spawning Chinook salmon have been in the low hundreds within the Middle Fork subbasin (including returns to Dexter trap and Fall Creek trap) and the population is at very high risk of extinction. An array of anthropogenic causes have likely contributed to this decline, but the primary cause of the decline for this population is elimination of nearly all of the historical spawning habitat by the construction of impassable dams low in the basin, and altered water temperature regimes downstream of the dams (Hills Creek, Dexter/Lookout) that cause poor egg survival (McElhany et al. 2007; ODFW 2007b). See the baseline chapter for more information.

In general, the Proposed Action includes the following broad on-the-ground actions:

- Project dams - current configuration, continued operation, and maintenance of Fall Creek, Dexter, Lookout Point, and Hills Creek dams in the Middle Fork Willamette watershed.
- Flow management - targets for volume and seasonal timing of water released downstream from Fall Creek and Lookout/Dexter dams.

- Ramping rates - targets would be intended to limit down-ramp rates below Fall Creek and Lookout/Dexter Dams to no greater than 0.1 ft/hr at night and to no greater than 0.2 ft/hr during the daytime.
- Hatchery program - continued production of hatchery Chinook for fishery augmentation and conservation purposes.
- Outplanting program - trap and haul of Chinook from below Fall Creek and Dexter dams to release locations above the dams.
- Dexter and Fall Creek adult fish collection facilities - rebuild both facilities in the future, date uncertain and based on funding.

The Action Agencies' assessment of the effects of the Proposed Action in the Middle Fork Willamette describes minimal to no reduction in the effects of their actions from the current baseline conditions (see Table 5.2-5 at the end of this section and Table 6-4 and Table 6-12 of the Supplemental BA, USACE 2007a). As described in the following subsections, NMFS agrees with the effects assessment of the Action Agencies in the Middle Fork Willamette watershed, meaning that the ESUs will continue to be at high risk of extinction.

5.2.1 Habitat Access & Fish Passage

Under the Proposed Action, Dexter, Lookout Point, Hills Creek, and Fall Creek dams would continue to block access to and from nearly all Chinook salmon spawning habitat in the Middle Fork Willamette watershed. The Action Agencies propose, as an interim measure, to continue experimentally transporting some adult UWR Chinook above Fall Creek, Dexter, Lookout Point, and Hills Creek dams (USACE 2007a, p. 3-47) providing a modicum of upstream passage, as noted in the baseline conditions. Downstream passage of juvenile salmon through these reservoirs and dams would continue to occur under the current configuration of the project, but would be ineffective. As noted in the baseline chapter (see section 4.2.3.1), no downstream passage routes are equipped with screen or bypass facilities to safely pass juvenile fish downstream. Though the Action Agencies propose to conduct studies to evaluate passage mortality over the term of the Opinion, no actions are proposed at this time to help improve downstream passage of juvenile salmon beyond the baseline conditions of current project configurations and operations.

While the Proposed Action would continue the interim, experimental outplanting program using truck transport, data so far indicate that, due to mortality of adults and juveniles from a number of causes, it is not effective in providing upstream and downstream fish passage and access to limited spawning habitat in the Middle Fork Willamette subbasin. As described in Section 4.2.3.1, UWR Chinook salmon access to habitat blocked by the dams in the Middle Fork Willamette is of critical importance because the remaining spawning habitat below the dams does not support adequate reproduction because of high mortality of incubating eggs (see section 5.2.3.1 for a full explanation). The habitat upstream of the dams is relatively high quality habitat for Chinook salmon and able to support successful reproduction, growth, and rearing of adult and juvenile fish (see section 5.2.3 below).

The practice of holding fish in the river below dams (rather than either trapping or passing them immediately) means that adult fish holding below dams have increased likelihood of trying to swim up into turbines, where they may experience severe injuries. Particularly when turbines are started and stopped, velocities in turbine tailraces are reduced to levels that are within the swimming abilities of UWR Chinook.

The key proposed actions related to habitat access in the Middle Fork Willamette watershed that will affect UWR Chinook salmon are the following:

- Continue to collect adult salmon at the base of Fall Creek and Dexter Dams using existing facilities, truck and haul the fish above the reservoirs, and release the fish in appropriate habitat to spawn.
- Continue to pass juvenile salmon downstream through the reservoirs and dams under current configurations. Flow operations would be as described in section 3.3 of the Supplemental BA.
- Conduct the "Willamette System Review Study" that will evaluate Dexter and Fall Creek adult collection facilities and downstream passage alternatives at Fall Creek, Dexter/Lookout, and Hills Creek dams and reservoirs. The actual order in which the Middle Fork Willamette would be studied among the other watersheds would be determined in Phases I and II of the study. However, the North Santiam was proposed to be first priority (USACE 2007a, page 3-143).

The following is an assessment of the effects of adult upstream passage via the outplanting program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.2.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Outplanting adult spring Chinook salmon above Fall Creek and Dexter dams, the lowermost impassable barriers in the watershed, began in the early 1990's (Beidler and Knapp 2005). The outplanting program was initially focused on benefitting bull trout by providing a food base (Chinook fry) and nutrients (Chinook carcasses) to habitat upstream of the dams since anadromous fish migration to the upper watershed was eliminated by the dams. The USACE found that some of the outplanted fish survived and reproduced. Therefore, in recent years (2002 to date), the outplanting program transitioned into a more formal program with the goal of increasing the spawning and natural production of UWR Chinook salmon above the impassable dams.

All adult Chinook arriving at the Fall Creek Trap are transported above the dam, with projected rates of injury of 1% and mortality of 1% at the fishway and an additional 1% mortality during transport (Willis 2008). Due to the outdated trap-and-haul facilities and operations (see below), levels of stress and delayed mortality are likely to be high and to contribute to the high levels of prespawning mortality in some years (also see below).

Some Chinook trapped at Dexter are transported above the dams (McLaughlin et al. 2008). Projected rates of injury and mortality at the Dexter Trap are 1% each, with another 2% mortality during transport (Willis 2008). Some of these fish are released at sites within the Middle Fork subbasin, including upstream of Hills Creek Reservoir. Levels of stress and delayed mortality are likely to be high (see above).

The success of the outplanting program in providing more natural production in the Middle Fork Willamette population above the dams has been limited, based upon available information. Outplanting, as presently carried out, does not provide effective upstream fish passage. However, until better measures are in place, this program is the only mechanism by which Chinook salmon can access historical habitat above the dams. The USACE monitored the survival of outplanted adult Chinook above Dexter/Lookout Point dams in 2004 through 2006 (Taylor et al. 2007). Taylor et al. (2007) revealed some important information that should be considered in future assessments of the outplanting program for increasing the viability of the Middle Fork Willamette Chinook population. First, the survival of outplanted adults varied substantially among the three years studied although the trapping facilities, trucking protocols, personnel, and overall returns to Dexter Dam were similar: prespawning mortality of outplanted adults was extremely high in 2004 and 2005 (>85%), but was very low in 2006 (<10%; (Figure 5.2-1), a circumstance that was common to spring Chinook populations throughout the Willamette Basin during the latter year (McLaughlin et al. 2008).

High prespawning mortality also occurs in adult fish residing below Dexter Dam. These fish have not been trapped, handled, or transported, but have been exposed to poor conditions (delay and crowding) while holding before spawning. Similar results have been observed in the South Santiam (Section 5.5.1.1) and the North Santiam (Section 5.6.1.1) with adult fish both outplanted above and residing below the Project dams (McLaughlin et al. 2008). In contrast, significantly lower prespawning mortality rates have been observed in the Clackamas and McKenzie rivers (Schroeder et al. 2006; McLaughlin et al. 2008) where adult Chinook are not delayed (or forced to reside) below Project dams for extended periods of time. In summary, stress and the delayed effects of injuries during trapping and handling are likely to contribute to high prespawning mortality of UWR Chinook outplanted above the Middle Fork projects. However, the relationship is not clear because other environmental conditions such as delay and crowding appear to cause prespawning mortality below the dams.

In 2004 and 2005 (the years when prespawning mortality was very high), adult Chinook were collected early in the return (late May-early June) and then outplanted above the dams because it was thought that leaving fish to reside in warm water below the dam before being outplanted was contributing to the high mortality rates. However, this approach did not seem to improve the survival of outplanted fish (Figure 5.2-1). The total number of spring Chinook collected at Dexter Dam was similar in two years of study when prespawning mortality differed (i.e., 5,600 fish in 2005 [high prespawning mortality] and 5,900 in 2006 [low prespawning mortality]). In addition, total returns to Willamette Falls were similar in 2005 and 2006 (36,600 and 37,000 fish, respectively; ODFW 2008c).

In contrast, adult Chinook outplanted later in the summer (e.g., August versus May/June) exhibited somewhat higher survival (Figure 5.2-1). Based on these data, it appears outplanting the fish closer to spawning time may contribute to spawning success above the dams. However, as a result of this approach, many of the fish held below Dexter Dam in warm water until August died. That is, only those that survived the holding period were transported and released above the dam, and survival to spawning of this group was relatively high.

Conclusion

The results to date on the success of outplanting adult salmon above the Middle Fork Willamette dams have been mixed. Overall NMFS expects that prespawning mortality would be with high the outplanting program under the Proposed Action. Improvements to the collection schedules, collection facilities, transporting protocols, and release locations will undoubtedly benefit the post-release survival of outplanted fish. However, until the causes of the high prespawning mortality rates in Chinook residing below these dams are known and addressed, NMFS anticipates that the Proposed Action will result in minor improvements to the success of the adult outplanting program.

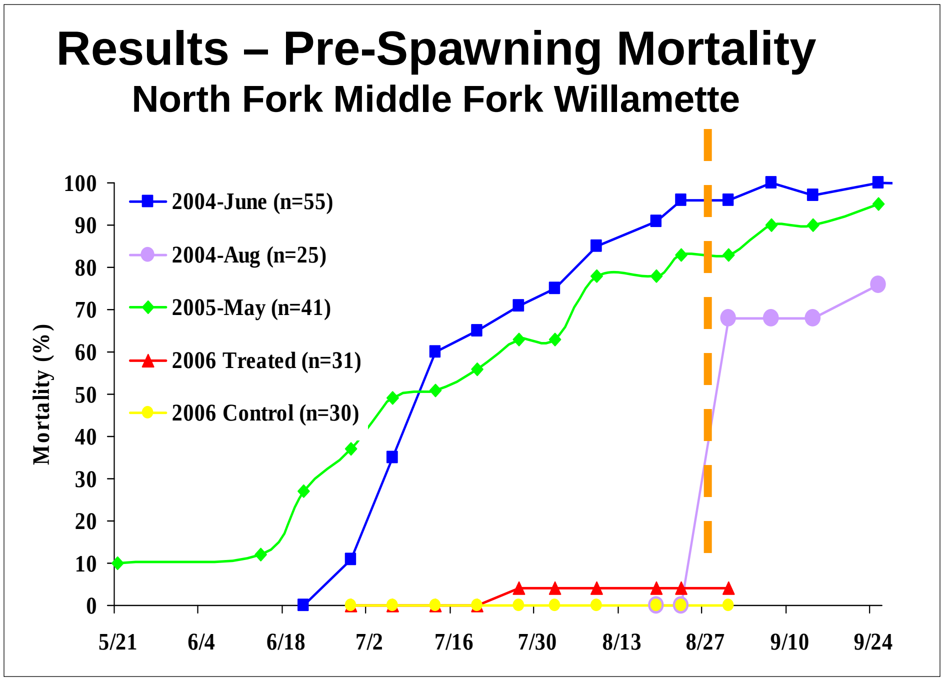

Figure 5.2-1 Prespawning mortality rates of radio-tagged spring Chinook released above Dexter Dam into the North Fork Middle Fork Willamette River, 2004-2006. Figure taken from Taylor et al. (2007).

Based on Taylor's et al. (2007) monitoring, prespawning mortality is not solely caused by the adult trap and transport program in the Middle Fork Willamette subbasin. However, the present facilities and operations are likely to contribute to poor adult survival. Physical handling during trapping, transport, and release stresses Chinook salmon, resulting in increased susceptibility to disease, possible delay in spawning, and in some cases, indirectly mortality. Risk is associated with even modern fish trapping, sorting, and transport operations, but the fish trapping and transport facilities on the Middle Fork (Dexter and Fall Creek facilities) are outdated and great risks.

The existing adult trapping facility at Dexter Dam was originally built to collect broodstock for the hatchery program (fish that will have their eggs taken in a hatchery setting) rather than to safely handle fish for outplanting purposes (fish must that survive until they can spawn on their own in the wild). The Fall Creek trap is somewhat better, although the facility does not meet current fish handling criteria and guidelines. Direct mortality of Chinook observed during the trap and haul activities is typically <1% of the fish handled (Willis 2008). Direct mortality losses have been higher on occasion, but these cases are usually attributable to an unforeseen circumstance, equipment malfunctions, or human error. The numbers of fish handled at the Fall Creek trap varies; 2,805 was the highest number during 2002-2007.

The Proposed Action requires only intermittent trap operation at Dexter Dam (USACE 2000, p. 2-55), which increases the likelihood that congregated fish immediately downstream of the turbines will experience turbine tailrace injuries.

The Fall Creek trap will also only be operated intermittently. There are no turbines at Fall Creek currently, though a private investor in the process of proposing to add hydropower generation facilities.

5.2.1.2 Juvenile Production

In 2006, when the prespawning mortality of adults was very low, juvenile production in the Middle Fork Willamette above Dexter and Lookout Point was substantial, with over 100,000 age-0 fry estimated to have emigrated downstream of the trap throughout the spring and summer of 2007 (Taylor 2008a). During January 2008, thousands of age-1 smolts have also emigrated by the trap location. Thus, when adult prespawning survival is good, the habitat can produce and support at least two age classes of juvenile Chinook salmon. Therefore, the habitat upstream of the dams is capable of producing and rearing spring Chinook salmon. Historically these areas were the primary places in the Middle Fork Willamette where Chinook salmon spawned and reared. In addition, these higher elevation habitats in the Cascades are in relatively good shape. The majority of this habitat is managed by the Federal government and applies some of the best aquatic and terrestrial management under the Northwest Forest Plan standards and guidelines.

5.2.1.3 Dam & Reservoir Survival

None of the four dams in the Middle Fork Willamette River subbasin (Dexter, Lookout Point, Hills Creek, and Fall Creek) is equipped with fish screens and bypass facilities to safely pass juvenile fish around turbines. As described in Section 4.2.3.1.2, Fall Creek Dam was equipped with “fish horns” intended to pass juvenile fish downstream, but these are not used for their intended purpose due to low collection efficiency and high fish mortalities in the bypass system. Juvenile UWR Chinook salmon that are produced above the dams must migrate downstream through the reservoirs and pass over or through the dams on their seaward migration. Data on the survival rates of juvenile Chinook through the reservoirs and dams in the Middle Fork Willamette are limited.

Hills Creek Dam

- Beidler and Knapp (2005) summarize a study conducted at Hills Creek dam by Larson (2000). In the fall of 1999, Larson estimated mortality rates for juvenile Chinook passing through the turbines and regulating outlets of 59% and 32%, respectively. Willis (2008) assumes a direct mortality rate from Hills Creek forebay to tailrace of 60%. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Hills Creek Reservoir has not been documented.

Dexter/Lookout Point

- Willis (2008) assumes 21% juvenile Chinook mortality between the Lookout Point forebay and Dexter Dam. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Lookout Point Reservoir has not been documented.

Fall Creek Dam

- Studies conducted in 1991 noted 41% mortality through the regulating outlet (Downey 1992). Rates of injury and potential delayed mortality have not been documented.
- Downey (1992) also reported 68.3% mortality through the "fish horns" associated with the "downstream migrant system" from the Fall Creek forebay to the Fall Creek Dam downstream migrant facility. Rates of injury and potential delayed mortality have not been documented.
- Survival/mortality through Fall Creek Reservoir has not been documented.

The Action Agencies propose to conduct studies to evaluate reservoir and dam passage mortality as described below.

Table 5.2-1. Numbers of outplanted spring Chinook and redds in the North Fork Middle Fork Willamette River. Table taken from Taylor et al. 2007.

OUTPLANT & REDD COUNTS		
North Fork Middle Fork Willamette		
Chinook Outplanted	Redd Counts (Est.)	Fish/Redd
578		
798		
1,650	35	46
3,765	166	22
1,695	18	91
2,864	84	34
798	42	19
827	363	2.3

Adult UWR Chinook salmon are outplanted upstream of the dams and reservoirs and thus have not been found in the reservoirs and do not pass the dams downstream. Their tendency is to continue upstream migrations to cool, headwater habitats for oversummering. Spring Chinook are semelparous and die after spawning. Thus, there is no concern about adults migrating downstream through the reservoirs and dams back to the ocean (e.g. unlike steelhead, which are repeat spawners).

The Proposed Action describes the Willamette System Review Study, a process that will be undertaken for the Willamette Project (all 13 Project dams in the Willamette Basin) to prioritize fish passage needs and improvements. However, the Action Agencies state that they cannot make a firm commitment to construct or carry out any fish passage facilities or operations indicated by the study because of uncertainty with obtaining authorization and funding (USACE 2007a). Other than studies, no specific actions are identified in the study proposal for the Middle Fork Willamette. NMFS therefore assumes that juvenile UWR Chinook salmon will continue to experience mortality rates like observed in the past-- 41% (turbines) and 19 to 68% (regulating outlets) per project for juvenile fish passing downstream through the dams in the Middle Fork Willamette River subbasin.

There is insufficient information with which to make any estimates of juvenile UWR Chinook mortality through the reservoirs.

Conclusion

The Proposed Action would continue to prevent safe access for UWR Chinook salmon to their historical habitat above the dams, and would continue to kill and injure large numbers of individual juvenile fish migrating downstream past the dams.

5.2.2 Water Quantity/Hydrograph

The Action Agencies propose to continue flow management as done since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge.

5.2.2.1 Seasonal Flows

The Corps has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.2-2).

Table 5.2-2 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the Middle Fork Willamette River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Flow	
Hills Creek	Sep 1 – Jan 31	Chinook migration & rearing	400	<1%			
	Feb 1 – Aug 31	Chinook rearing	400	<1%			
Fall Creek	Sep 1 – Oct 15	Chinook spawning	200	5%	400 Through Sep 30, when possible	25%	Sep
	Oct 16 – Jan 31	Chinook incubation	50 [3]	<1%			
	Feb 1 – Mar 31	Chinook rearing	50	<1%			

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Flow	
	Apr 1 – May 31	Chinook rearing	80	<1%			
	Jun 1 – Jun 30	Chinook rearing / adult migration	80	<1%			
	Jul 1 – Aug 31	Chinook rearing	80	5%			
Dexter	Sep 1 – Oct 15	Chinook spawning	1,200	<1%	3,500 Through Sep 30, when possible	10% 45%	Sep Oct
	Oct 16 – Jan 31	Chinook incubation	1,200 [3]	<1%			
	Feb 1 – June 30	Chinook rearing	1,200	<1%			
	Jul 1 – Aug 31	Chinook rearing	1,200	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation.

3 When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed minimum flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the Middle Fork basin. In general, the more often these objectives are met, the better the conditions for salmon and steelhead survival. Nevertheless, when these flows are not met (projected at 1% of the time) adults Chinook will encounter less spawning and holding habitat and juveniles will be subjected to desiccation of eggs, barriers to shallow water rearing areas and entrapment during fluctuations at low flows (Willis 2008). When these adverse effects occur, the effect will extend over the reach from Fall Creek Dam to the creek's confluence with the Middle Fork Willamette (about 7 miles), from Dexter Dam to the confluence of the Middle Fork with the Coast Fork Willamette (about 17 miles), and from Hills Creek Dam to the upstream end of the Lookout Point Reservoir (about 9 miles) (Willis 2008.) These flows closely correlate with fish management agencies' recommendations and the best currently available information. NMFS considers these proposed operations, which would miss the minimum flow objectives <5% (and often <1%) of the time to be highly protective.

Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

The Action Agencies also propose to conduct instream flow compliance and effectiveness monitoring and may also conduct limited experimental operations to determine if the proposed water management operations meet the needs of anadromous fish. As these data become available, NMFS anticipates that water management programs would be modified as necessary to meet anadromous fish needs. Because it is unclear whether such investigations would result in any changes in project operations, we cannot assume any benefit to anadromous fish at this time.

5.2.2.2 Frequency of Channel-forming & Over-bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream of Fall Creek and Dexter dams, project operations would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon in Fall Creek and the Middle Fork Willamette River downstream. Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon. Although these habitat-altering processes would continue under the proposed action, water quality issues (primarily water temperatures) are considered to be the most likely causes of poor reproductive success in the Middle Fork Willamette River and its tributaries. If these water quality issues are favorably resolved, habitat alteration issues associated with peak flow reduction might limit reproductive success.

Given the low level of current use of the Middle Fork Willamette River by spawning and rearing spring Chinook and the limitation on success posed by high water temperatures, the effect of peak flow reduction in the Middle Fork watershed likely has only a small effect on the ESU at present. Once the temperature concerns are successfully resolved, the habitat-limiting effects of peak flow reduction could then limit the abundance, productivity, and juvenile outmigrant production of the population. The USACE does not propose any actions to investigate or reduce these effects. These effects are expected to continue and may worsen over the life of the proposed action.

Reduction of peak flows in ongoing flood control operations could continue to benefit spring Chinook salmon by reducing the likelihood that high flows would scour and disrupt salmon eggs incubating within redds (compared to the unregulated condition). However, the rate at which flows are reduced during flood control operations is also a factor (see below).

5.2.2.3 Flow Fluctuations

The Action Agencies propose to operate Project dams in an effort to meet an 0.1 ft. per hour downramping rate restriction during nighttime hours and an 0.2 ft. per hour rate restriction during daylight hours, when possible. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992). Based on the best available information, NMFS assumes that meeting this commitment would be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment of juvenile salmonids downstream of Project dams as long as existing equipment at the dams allows the USACE to operate within the proposed restrictions. However, the Action Agencies have indicated that the USACE will be unable to meet these ramp rate restrictions during periods when flow releases approach proposed minimums (USACE 2007a). This suggests that the proposed protections of juveniles against rapid flow changes may be inadequate to prevent losses. Results of studies that the Action Agencies have proposed for evaluating the effectiveness of their efforts to control ramp rates below Project dams will address this issue and may indicate a need for improved ramp rate controls.

5.2.2.4 Water Contracting

The USACE's Middle Fork projects are lightly used for water supply purposes. Reclamation has contracted a total of 253 acre-feet of water from the USACE reservoirs for irrigation within the Middle Fork subbasin. This use would increase dramatically under the proposed action as the Reclamation intends to issue contracts to an additional 813 acre-feet of water stored in USACE's Middle Fork basin projects and has proposed to issue contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[1]

The USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the proposed action more water would be removed from the Middle Fork Willamette River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water service contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by ODWR. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water use could reduce flows in some sections of the Middle Fork Willamette River by about 7.7 cfs. Summer low flows at the USGS's Jasper, Oregon gage have seldom fallen below 400 cfs with a minimum for the period of record of 366 cfs. Thus the total amount of project-supported flow reduction would be about 2 percent of the lowest flows observed in the river. Also, the effects of water withdrawals on juvenile rearing habitat in the Middle Fork Willamette River are mitigated during July and August in most years when it becomes necessary to release water stored at the Hills Creek, Lookout Point, Dexter, and Fall Creek reservoirs to maintain the Albany and Salem minimum flows. The annual fall drawdown reduces the impact of September water withdrawals. By October, irrigation water use is substantially reduced and the streamflows tend to be increasing as the western Oregon rainy season begins. The proposed level of water service to be provided by Reclamation under the proposed action is not expected to appreciably impact anadromous salmonids in the Middle Fork Willamette River watershed.

5.2.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management action. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-

[1] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, less than one-half percent (40 acre-feet) would be issued to serve areas in the Middle Fork subbasin.

listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.2.3 Water Quality

Water temperature and dissolved gas supersaturation are important water quality characteristics that are affected by operation of the dams in the Middle Fork Willamette and which influence natural production of UWR Chinook salmon in habitat downstream of the dams. The Proposed Action would continue operation of the Projects as has occurred since 2000. The details of these actions are described in the Supplemental BA (USACE 2007a). The water quality is degraded because temperatures are warmer when they should be colder, and vice versa, as well as having high TDG and toxics levels. A summary of the effects of the Proposed Action on all of the water quality attributes is described in Table 5.2-5.

5.2.3.1 Water Temperature

Spring Chinook are ectothermic, meaning that their body temperature is regulated by the surrounding water; thus water temperature significantly affects survival, development, growth, migrations, and diurnal movement of salmon in both the fresh- and salt-water (Quinn 2005). In the Willamette River Basin, water temperatures below the dams have an important effect on adult migrations upstream, prespawning mortality, egg survival and development, and juvenile growth. Lower temperatures than normal below dams contribute to pre-spawner straying and mortality for adult Chinook; for juveniles, elevated temperatures cause reduced egg viability and increase susceptibility to disease. These effects extend from Dexter Dam to the confluence of the Willamette and McKenzie rivers, approximately 17 miles; from Fall Creek Dam to the confluence of the Middle Fork, approximately 7 miles; and from Hills Creek Dam to upper end of the Lookout Point Reservoir, approximately, 9 miles (Willis 2008).

Under the proposed action, the temperature of water released from Fall Creek, Hills Creek, and Lookout Point/Dexter dams would continue to be altered as compared to pre-dam conditions. Water is colder in the summer and warmer in the fall (e.g., Figure 5-2.2). NMFS anticipates that few fish would survive to spawn in the reach below the dams and the available information suggests egg survival would continue to be very low due to high temperatures during the incubation period in the fall. Taylor and Garletts (2007) reported in a study of egg survival above and below Dexter/Lookout Point dams that 100% of the eggs incubating below Dexter Dam died before emergence. The eggs began to show signs of fungus growth as soon as 10 days after fertilization. Only one sac-fry developed enough to hatch, but was deformed and died. In contrast, 81% of the eggs incubating in natural water temperatures in Salmon Creek (an unregulated stream above the dams) survived to the swim-up fry stage.

For those few eggs that may survive below Dexter Dam, accelerated development allows the alevins to emerge from the gravel earlier than would occur naturally. Emergence during winter flow conditions has been shown to reduce juvenile fish survival because alevins are exposed to scouring flows associated with winter freshets. Using a different method of analysis, Taylor and Garletts (2007) compared hatch and emergence timing of juvenile spring Chinook from below and above Dexter Dam based on cumulative temperature units (Figure 5-2.2). He estimated an emergence date for eggs incubating below Dexter Dam to be November 18th, compared to February 1st for eggs incubating in natural water temperatures upstream—a difference of approximately 2.5 months (Figure 5.2-3).

The Action Agencies propose to continue operating the dams under current configurations and flow regimes. No water temperature control structures or operational changes that could decrease the temperature problems associated with the dams are proposed for the Middle Fork Willamette.

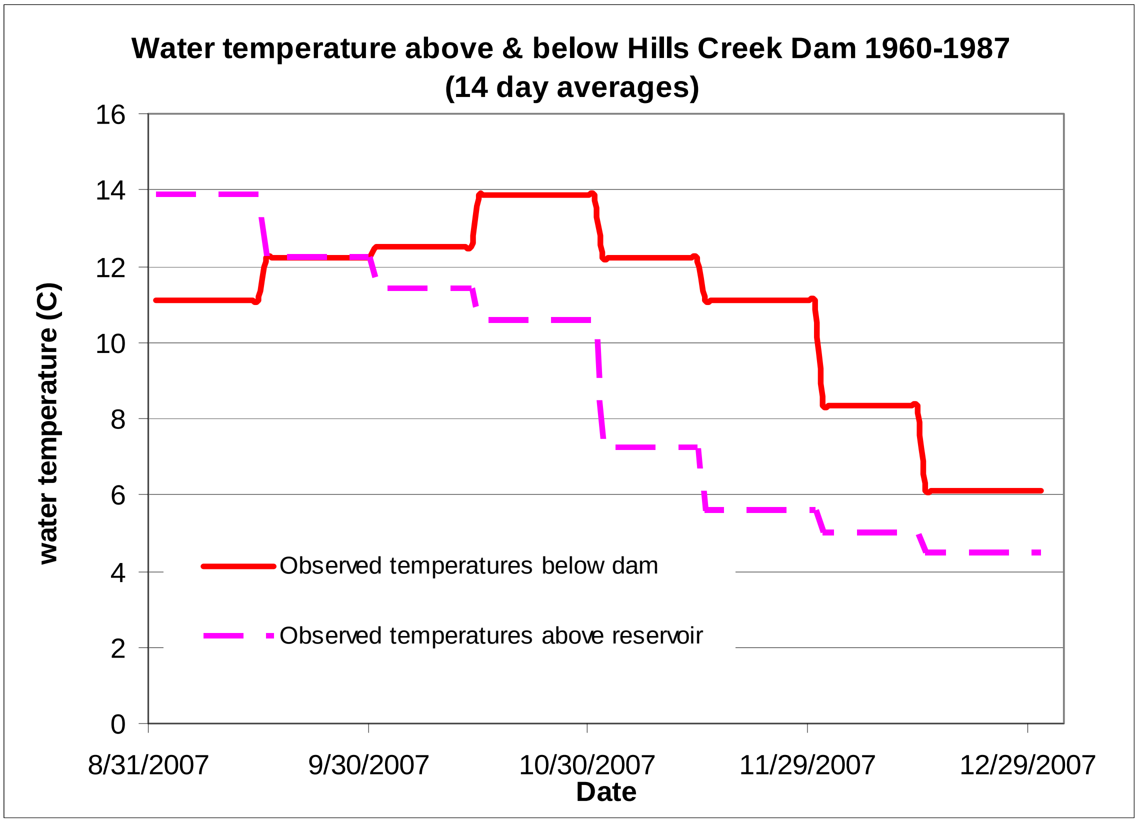

Figure 5.2-2 Comparison of observed water temperatures above Hills Creek reservoir (natural temperatures) and below Hills Creek dam (altered temperatures) in the Middle Fork Willamette during Chinook spawning and egg incubation. Data are 14 day averages from 1960-1987.

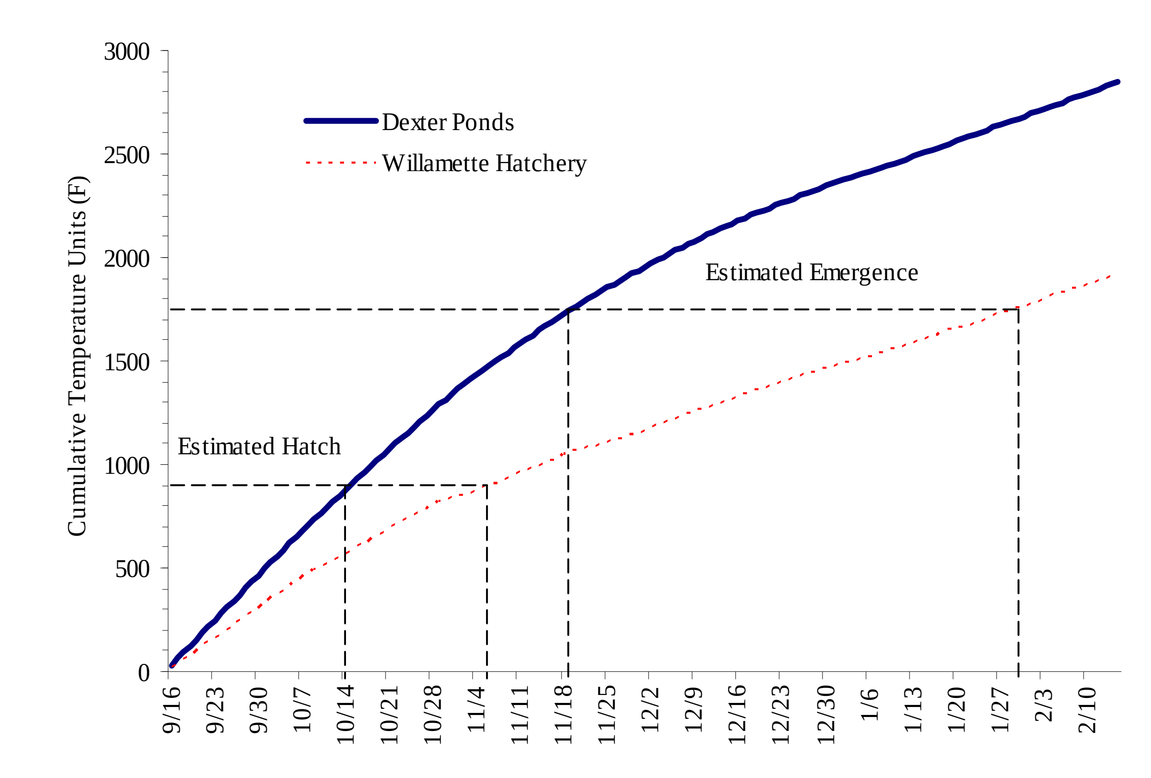

Figure 5.2-3 Comparison of estimated hatch and emergence timing of spring Chinook incubating in natural water temperatures above Dexter Dam (Willamette Hatchery) and altered water temperatures below Dexter Dam (Dexter Ponds). Figure taken from Taylor et al. (2007).

5.2.3.2 Total Dissolved Gas (TDG)

Dissolved gas concentrations exceeding 105% of saturation (i.e., supersaturated), which can be detrimental to spring Chinook eggs and alevins, have been observed downstream from Dexter Dam (Monk et al. 1975). Because most of spawning occurs near the dam, it is likely that eggs would be exposed to elevated dissolved gas levels. The extent of TDG-related juvenile mortality has not been documented, but it is reasonable to assume that some occurs when spill operations and flow management drive TDG above 105% at the redd level during the fall and winter periods. TDG effects are assumed to extend one mile below Dexter and Fall Creek dams. (Willis 2008).

Hills Creek Dam
Spill over 1,500 cfs can generate more than 110% TDG at the surface (100% at the gravel assuming an average depth of about 1 m) below Hills Creek Dam. In most years, spill stays below this level. The winter of 1996 was an exception: 25 days in January, 10 days in February, 11 days in November, and 15 days in December (Willis 2008).

Dexter Dam
Spill over 1,000 cfs through 1 spillway bay at Dexter Dam generates more than 115% TDG at the surface (about 105% at the gravel) below Dexter Dam. In most years, spill stays below this level (exceeded about 30% of the time during January 1996) (Willis 2008).

Fall Creek Dam

Spill over 1,500 cfs generates more than 110% TDG at the surface (about 100% at the gravel) below Fall Creek Dam. In most years, spill stays below this level. The winter of 1996 was an exception: 21 days in January, 5 days in February, 13 days in November, and 10 days in December (Willis 2008).

5.2.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Middle Fork Willamette subbasin that will affect UWR Chinook salmon are the following:

- Continue to operate Dexter, Lookout Point, Hills Creek, and Fall Creek dams, blocking sediment and large wood transport from upstream reaches and tributaries into the lower Middle Fork Willamette River and Fall Creek.
- Continue to reduce peak flows as part of flood control operations at the four dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 1.47 miles of revetments along the lower Middle Fork Willamette River, preventing channel migration and reducing channel complexity.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.
- Continue the Willamette Floodplain Restoration Study, including focus on mechanisms to provide channel-forming flows from Project dams in the Middle Fork Willamette subbasin and possibly testing peak flow releases.

5.2.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity in the Middle Fork Willamette Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.2.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.2-5 and described below. These effects occur year-round and extend from:

- Dexter Dam to the confluence with the Coast Fork Willamette River, about 17 miles.
- Fall Creek Dam to the confluence with the Middle Fork Willamette River, about 7 miles.
- Hills Creek Dam to the upstream end of the Lookout Point Reservoir, about 9 miles (Willis 2008).

Under the Proposed Action, operation of Dexter, Lookout Point, Hills Creek and Fall Creek dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. These habitat features are used by UWR Chinook salmon for rearing and spawning, and when substrate is coarsened and side channels deprived of new sediment, macroinvertebrate productivity decreases, reducing food availability for rearing fish, and redd construction and egg survival is likewise reduced (See Appendix E for summary of fish and habitat relationships). As described in section 4.2.3.4, operation of the USACE dams in the Middle Fork Willamette has trapped gravel and large wood from 90% of the Middle Fork Willamette subbasin and has reduced the magnitude of peak flows. As a result of both the altered hydrologic regime and the dams acting as barriers to sediment transport, fish rearing and spawning habitat below the dams would continue to be degraded by substrate coarsening and the inability to create new gravel bars, islands, and side channels.

The Proposed Action additionally includes continued existence and maintenance of 1.47 miles of revetments in the lower Middle Fork Willamette River. The revetments would continue to prevent the recruitment of gravel from the floodplain and would limit lateral migration of the channel. The reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

The continued degradation of habitat downstream of Dexter and Fall Creek dams would likely further reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon that can be produced in this presently degraded habitat. Because adults do not have access to historical spawning grounds upstream of Dexter Dam, a reduction in spawning habitat in the reaches below Dexter could further limit spawning or contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). A lack of complex rearing and refugia habitat in both the mainstem Middle Fork Willamette and its tributaries could also limit juvenile production in the subbasin, particularly since the temperature regime in this river is high enough to cause the early emergence of fry in winter months, when fry need refuge from high waters (see Section 5.2.3 Water Quality, above). Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study and other proposed studies related to gravel augmentation and other habitat features, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Middle Fork Willamette subbasin.

5.2.4.2 Riparian Vegetation & Floodplain Connectivity in the Middle Fork Willamette Subbasin

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.2.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.2-5 and described below.

Under the Proposed Action, operation of the Willamette Project and continued existence and maintenance of 1.47 miles of revetments in the lower Middle Fork Willamette River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that creating new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the lower Middle Fork Willamette River associated with Project operations (as described in Section 5.2.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in

Section 5.2.1 Habitat Access/Fish Passage), further degradation of physical habitat characteristics would reduce what little habitat remains available to the UWR Chinook salmon population in the Middle Fork Willamette subbasin.

The extent and function of the Middle Fork Willamette subbasin's riparian vegetation and floodplains have been and would continue to be impaired by operation of the Willamette Project under the proposed action. Hills Creek Reservoir inundated approximately 200 acres of riparian hardwoods, while Lookout Point and Dexter reservoirs inundated another 2,025 acres of riparian forest along the Middle Fork Willamette River. Fall Creek Reservoir inundated approximately 6.8 miles of riparian vegetation along Fall Creek. USACE revetments replaced approximately 4 miles of riparian vegetation along the Middle Fork Willamette River, such that 50% of the banks below river mile 19 are hardened (USACE 1989b). 1.47 miles of these revetments would be maintained by the USACE under the proposed action.

The flood control afforded by the Willamette Project in the Middle Fork Willamette subbasin has probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the proposed action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

As described above in sections 5.2.4.1, operation of Hills Creek, Lookout Point, Dexter, and Fall Creek dams would continue to trap gravel and large wood and reduce the magnitude of peak flows in the Middle Fork Willamette subbasin. Both of these operations deprive downstream reaches of material and transport mechanisms needed to create new gravel bars and floodplains on which new riparian vegetation can establish. Additionally, USACE revetments would continue to prevent river migration and contribution of sediment from 1.47 miles of streambank in the lower Middle Fork Willamette, further depriving the river of sediment and the ability to construct new surfaces on which riparian vegetation can establish.

Conclusion

The proposed operation of the Willamette Project would continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the Middle Fork Willamette subbasin downstream of Dexter and Fall Creek dams. This limits recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Reduced inundation of forested floodplains limits nutrient and organic matter exchange during flood events, and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Middle Fork Willamette subbasin. Given the lack of upstream and downstream passage to historical habitat above Project dams, and the limited habitat below the dams for spawning, rearing, and holding, continued degradation of this habitat under the Proposed Action would put the Middle Fork Willamette population of UWR Chinook salmon at even higher risk of extinction than its current status.

5.2.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock # 22) and summer steelhead (ODFW stock # 24) and release these fish into the Middle Fork Willamette River at Dexter Dam. Further details about these programs are described in the Middle Fork Willamette spring Chinook HGMP (ODFW 2003) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook in the Middle Fork Willamette.

5.2.5.1 Hatchery Operations

There are two hatchery facilities located within the Middle Fork watershed. The broodstock collection facility is located at the base of Dexter Dam. The Willamette Hatchery, used to incubate and rear hatchery fish, is located upstream of Dexter and Lookout Point Reservoirs on Salmon Creek, a small tributary to the Middle Fork Willamette. As described above in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook in the Middle Fork- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below.

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook at the Willamette Hatchery has been very low over the last several decades because facility failures have resulted in few mortalities in the past and there is a very low percentage of wild fish offspring being reared at this hatchery (Table 5.2-3). Therefore, NMFS considers this risk to continue to be very low.

The water intake for the water supply at Willamette Hatchery is located on Salmon Creek. Due to the significant problems associated with the adult outplanting program to date to re-establish natural production above Dexter/Lookout Dams, the presence of juvenile Chinook in the area of Willamette hatchery is likely to be minimal. Most of the observed juvenile production of Chinook has been downstream of the hatchery in the North Fork of the Middle Fork Willamette. The extent of designated critical habitat in Salmon Creek is limited to the lowermost reach of the creek. A significant barrier to fish occurs just upstream of the hatchery intake—limiting the habitat available to juvenile and adult Chinook. Even though the water intake at the hatchery does not meet NMFS criteria for listed juvenile fish, the risk of juvenile fish being taken into the hatchery's water supply is very low due to the lack of juvenile Chinook in Salmon Creek at this time.

Table 5.2-3 Composition of spring Chinook salmon without fin clips that were spawned at Willamette Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. (from McLaughlin et al. (2008).

	Unclipped[a]		Fin-clipped	Percent wild	
Year	Wild	Hatchery	hatchery	in broodstock	of run
2002	5	53	1,602	0.3	---
2003	5	59	1,465	0.3	---
2004	16	28	1,807	0.9	---
2005	19	24	1,497	1.2	---
2006	45	55	1,608	2.6	---

[a] *Includes fish with partial or questionable fin-clips.*

5.2.5.2 Broodstock Collection

Dexter Dam

The Dexter broodstock collection facility is located at the base of Dexter Dam. When the trap is opened at the dam, spring Chinook enter volitionally. The fish collected are either used for broodstock or are trucked upstream of the dam and released to spawn in historically occupied habitat. During the period 2000-2006, between 5,541 and 11,375 Chinook were collected each year at the Dexter trap. Willis (2008) estimates <1% injury and 1% mortality during handling, and an additional 2% mortality during the subsequent truck transport operations (Willis 2008). Even though the direct levels of injury and mortality of spring Chinook during the collection process are low, significant handling stress does occur. The facility was designed only for hatchery broodstock collection; significant crowding of fish occurs and fish are transferred out-of-water between the holding pond and the trucks. These conditions are thought to contribute to the chronically high levels of post-release, prespawning mortality of adult spring Chinook (Section 5.2.2.1). However, high levels of prespawning mortality occur throughout the subbasin and the other contributing factors are unknown.

The Action Agencies have proposed to rebuild the collection facility at Dexter Dam to allow build trapping, handling, sorting, and loading of hatchery and wild spring Chinook salmon. The schedule for completing the new trap is not specified in the Supplemental BA, thus NMFS cannot rely on this actions to occur or on the accrual of benefits to the Middle Fork Willamette Chinook population.

Fall Creek Dam

During the period 2000-2007, between 339 and 2,805 Chinook were collected each year at the Fall Creek trap. Willis (2008) estimates <1% injury and <1% mortality during handling, and an additional 1% mortality during the subsequent truck transport operations (Willis 2008). Even though the direct levels of injury and mortality of spring Chinook during the collection process are low, significant handling stress does occur.

The Action Agencies have not proposed to rebuild the collection facility at Fall Creek Dam.

5.2.5.3 Genetic Introgression

Significant genetic introgression from hatchery fish into the natural population in the Middle Fork Willamette River has occurred since this mitigation program was initiated in the 1950's. Ever since all returning hatchery fish have been mass marked (adipose finclipped) so that they could be distinguished from naturally-produced fish in 2002, nearly all of the returns have been hatchery fish (see section 4.2.2.1 and Figure 4.2-3). In addition, nearly of the fish spawning naturally below Dexter Dam have been hatchery fish (Table 5.2-4). The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 4% to 18% from 2002-2005. Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock has been very low (see Table 5.2-3, above). Thus the PNI values for this population have been very low since 2002, indicating hatchery fish are dominating genetic processes in this population (Figure 5.2-4).

Table 5.2-4 Composition of spring Chinook salmon in the Middle Fork Willamette subbasin based on carcasses recovered. Source: McLaughlin et al. (2008).

	Fin-	Unclipped[a]		Percent
River (section), run year	**clipped**	**Hatchery**	**Wild**	**wild[b]**
Middle Fk Willamette (Dexter–Jasper[c])				
2002	228	91 (85)	16	5
2003	62	48 (92)	4	4
2004	120	32 (59)	22	13
2005	37	10 (50)	10	18

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution.
[c] Including Fall Creek. Data on clipped fish in spawning population were incomplete for 2006.

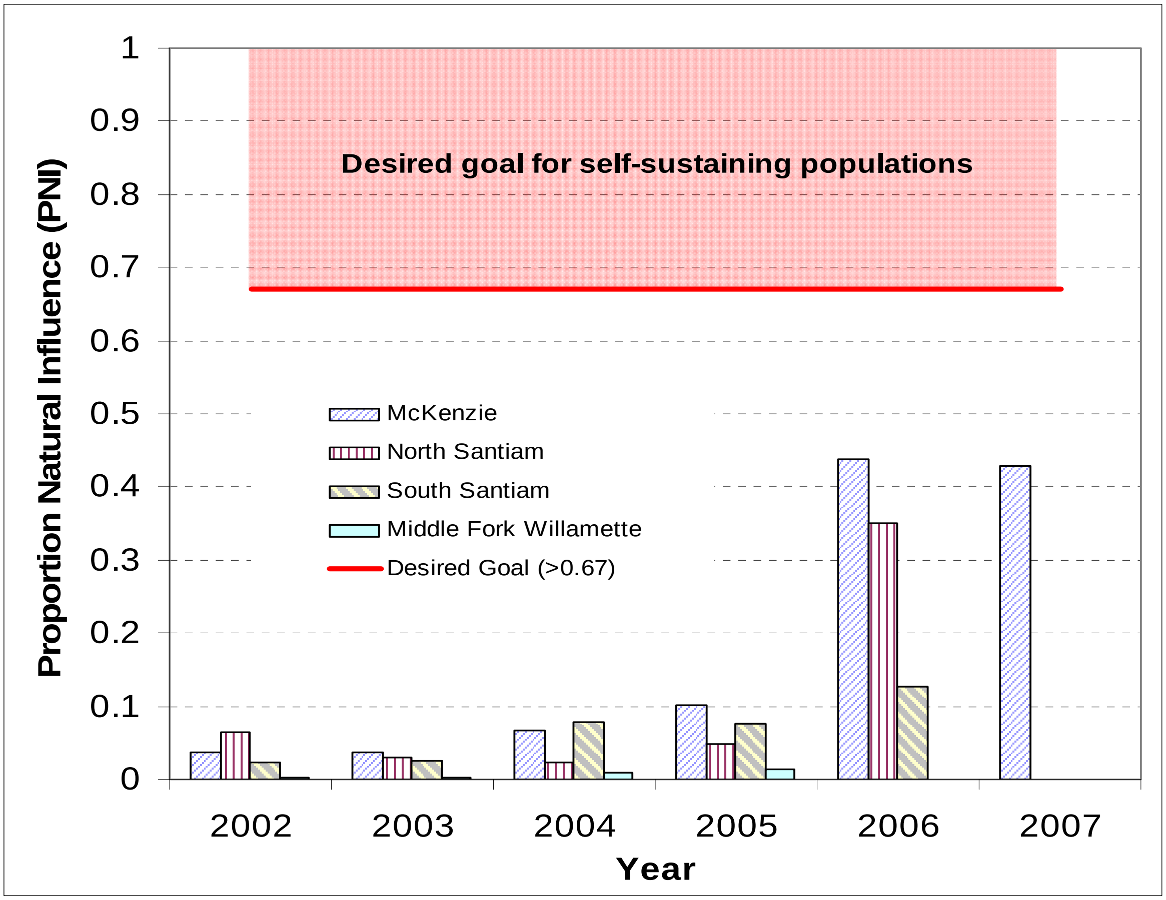

Figure 5.2-4 Proportionate natural fish influence (PNI) in four Chinook salmon populations within the Willamette Basin. PNI is an index of the influence of hatchery or natural fish within a population. PNI values greater than 0.67 indicate relatively low hatchery influence within a population (the desired goal for a naturally, self-sustaining population that does not rely on the continual support from artificial propagation).

The influence of hatchery fish should not be reduced until significant improvements are made to address the causes for the lack of natural production in this population. The reason why hatchery fish are influencing this population to a substantial degree is because there are so few natural-origin fish returning (<100 in recent years). The root causes for the lack of wild fish production must be addressed before any improvements in the hatchery situation can be made. The current spring Chinook hatchery program could be eliminated entirely and natural production in this population would not improve substantially due to the lack of historically habitat currently available and the temperature problems for incubating eggs downstream of Dexter Dam in the fall (see the discussion of these effects above). The current hatchery program is a consequence of the choices that were made in the 1950's to mitigate for fishery losses associated with the construction and operation of Fall Creek, Dexter, Lookout Point, and Hills Creek dams in the Middle Fork spring Chinook population.

5.2.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the Middle Fork Willamette subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon is low. The hatchery fish are released as smolts from Dexter Dam, located low in the watershed, thus interaction with wild juveniles is minimized. In addition, natural production is so poor in this population, not many wild fish are present in the area where hatchery fish are released.

The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section "Mainstem Willamette River."

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the area below Dexter Dam. Since this dam is located low in the watershed, spring Chinook have a tendency to congregate at the base of the dam. Thus, thousands of fish are residing together which increases the risk of spreading any kind of disease. Available information suggests the adults that die before spawning have a variety of pathogen and bacterial infections (Schroeder et al. 2006). However, it is unknown whether hatchery fish elevate the disease outbreaks in wild fish.

5.2.5.5 Competition/Density Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Given the poor natural production within the Middle Fork Willamette population, particularly downstream of Dexter Dam, where juvenile hatchery fish are present, it is unlikely competition between hatchery and wild Chinook is occurring at an adverse level of effect.

Adults
Given the problem of crowding of adult Chinook at the base of Dexter Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.2.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

5.2.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.2.5.8 Fisheries

As discussed in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead (of either natural or hatchery origin) are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13) in the Fisheries section of the Environmental Baseline chapter). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.2.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose fin-clipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during fin-clipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.2.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery-origin Chinook are also outplanted alive above the dams in an effort to restore natural production in historical habitats. This provides benefits to aquatic and terrestrial food chains.

5.2.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS’ (2000) *Biological Opinion on the impacts from the collection, rearing, and release of listed and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette (NMFS 2000a).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.2.6 Summary of Effects on the Middle Fork Willamette Chinook Salmon Population

Below is a summary of the effects of the Proposed Action on the four Viable Salmonid Population (VSP) parameters (abundance, productivity, spatial structure, and diversity) for the Middle Fork Willamette Chinook salmon population. These VSP parameters are described in detail in Section 3. All four of the VSP parameters for the Middle Fork Willamette spring Chinook population are at very risk levels (ODFW 2007b).

Abundance

The current abundance of naturally-produced Chinook salmon in the Middle Fork Willamette population is very low. The current status of this population is at very high risk of extinction (see Chapter 3, Rangewide Status). The latest available information indicates naturally-produced fish returns to the base of Dexter and Fall Creek dams (the lowermost dams) and spawning below these dams was likely in the range of 200-300 wild fish from 2005-2007 (Schroeder et al. 2006; McLaughlin et al. 2008; Taylor 2008b). Most of the wild Chinook production appears to be coming from above Fall Creek Dam, and virtually no wild Chinook production occurs above or below Dexter Dam. The abundance of hatchery-origin Chinook returning to the Middle Fork Willamette is comparatively very high and stable (NMFS 2004b).

The Willamette/Lower Columbia Technical Recovery Team has identified the Middle Fork Willamette as a “large” and “core” population for the ESU. In order for this population to be considered viable (less than 5% risk of extinction), the geometric mean abundance over the long term should exceed 700 to 1,400 naturally-produced, wild spring Chinook (WLCTRT and ODFW 2006). The draft Recovery Plan for UWR Chinook salmon (ODFW 2007b) states the Middle Fork Willamette population would be at low risk if it had an average abundance of 2,000-2,600 natural fish. Thus, significant survival improvements are necessary to improve the populations’ current status of very high risk.

Taking into account existing conditions and analysis of effects described above, the Proposed Action would continue to restrict natural production of UWR Chinook salmon in the Middle Fork Willamette watershed. The elimination of nearly all of the historical spawning and rearing habitat in the watershed due to the construction of Fall Creek, Dexter, Lookout Point, and Hills Creek dams has been the primary factor leading to the current low abundance of this population. In addition, the high prespawn mortality rates observed with Chinook (predominately of hatchery-origin) throughout the summer residing below Fall Creek and Dexter Dams and outplanted above the dams has greatly limited spawning success and, the number of offspring produced for the next generation.

Given the relatively high return of hatchery fish every year to the base of the dams, efforts to reintroduce Chinook back into their historical habitat have been occurring using hatchery fish. The results of these outplanting efforts have been variable and unpredictable. In most years, high prespawn mortality rates limit the number of hatchery fish that spawn. However, in certain years, as observed in 2006 when adult mortality rates were significantly lower throughout all of the Chinook populations in the Willamette, hatchery fish have spawned and produced significant numbers of juvenile offspring. However, it is not known what proportion of these juvenile Chinook survive the emigration through the large reservoirs and high-head dams that have no juvenile fish passage facilities. Information to date suggests survival through the dams varies depending upon migration timing and operations, but likely ranges from 20-60% (see above section “Reservoir and Dam Survival.”

Given the poor returns of wild Chinook to this population and the continuing adverse effects of the Proposed Action on the species and PCEs of critical habitat in the watershed, NMFS expects population abundance to continue to decline under the Proposed Action.

Productivity

A viable salmon population has a productivity rate (or recruits per spawner) that is equal to or greater than one (McElhany et al. 2000). In other words, a population that is not replacing itself is not viable over the long term. Productivity of the Middle Fork Willamette population has been declining over the long- (>50 years) and short-terms (<6 years). Given the long-term decline of wild Chinook in this population from tens of thousands of fish before 1950 to the current two to three hundred fish, significant improvements in productivity are needed in order for this population to increase in abundance. Survival increases are needed in adult survival, egg incubation, and juvenile downstream passage in order for the productivity rate to be greater than one over several generations. However, NMFS does not expect productivity of this population to improve under the Proposed Action as a result of 1) continued limited and degraded spawning habitat below Dexter and Fall Creek dams; 2) low survival of eggs from redds in this habitat caused by adverse water temperatures released from Project dams; and 3) lack of access to upstream habitat capable of producing more fish.

Spatial Structure

The spatial structure of the Middle Fork Willamette UWR Chinook salmon population has been severely constrained due to the lack of or very inadequate passage at the four Project dams in the watershed. Over 95% of the historical spawning habitat is currently not naturally accessible to Chinook. Access to the upstream habitat is dependent upon the fish being captured, transported, and released above the dams and reservoirs. Juvenile Chinook movement within the watershed is constrained by the large reservoirs and dams. The dams do not inhibit downstream movement of juveniles, although mortality is high, but upstream movement by juveniles throughout the watershed cannot occur. The use of hatchery fish for outplanting above the dams has provided some spatial structure benefits to the population by allowing fish to access historical habitats. The success of this program has been mixed; depending upon adult survival. The Proposed Action identifies possible improvements to existing traps at Dexter and Fall Creek dams that, if funded and carried out, would improve upstream passage to this habitat. Additionally, the Proposed Action includes studies conducted as part of the Willamette System Review Study that could result in downstream fish passage facilities at one or more of the dams. However, no certainty is provided that the studies will be funded or improvements will be made at the dams during the term of this Opinion. Consequently, until adequate upstream and downstream passage facilities are provided at some (or all) of the projects, the spatial structure of this population will continue to be severely impacted by the Proposed Action.

Diversity

Since the Middle Fork Willamette UWR Chinook salmon population is at very high risk of extinction and the abundance and productivity of this population is depressed, its natural life history diversity is simplified. Due to the high mortality rates of adults and juvenile migrating downstream through the reservoirs and dams, there are strong selective pressures that allow only a small segment of the population to survive in these altered conditions. Consequently, there is likely to be only certain life history types that survive and reproduce, thus confining the natural life history diversity needed for a healthy population to survive over the long term under varying environmental conditions.

In addition, the continual and widespread spawning of hatchery fish in all areas continues to pose risks to the long term survival and diversity of a potentially reestablished natural population. Once the primary limiting factors of habitat access and fish passage through the reservoirs and dams are corrected, the hatchery program will have to be managed to limit the effects of hatchery fish on the recovering wild population. The Proposed Action will not manage the effects of the hatchery on diversity until more wild fish return to the population and can be incorporated as broodstock.

Conclusion for Middle Fork Spring Chinook

Significant improvements to the status of the Middle Fork spring Chinook population are necessary in order to improve the viability of the ESU as a whole. Historically, this population may have been the most abundant in the ESU, but now is at “very high” risk of extinction. The likelihood of improving the status of this population, considering the Environmental Baseline, Proposed Action, and Cumulative Effects, is low. Re-establishing natural production in historical habitats above Project dams is of critical importance.

5.2.7 Effects of the Proposed Action on Designated Critical Habitat

- The Middle Fork Willamette River and a number of its tributaries have been designated as Critical Habitat for UWR Chinook salmon. Table 5.2-5 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the Middle Fork and Fall Creek, and USACE maintenance of 2.86 miles of revetments. The following PCEs will be adversely affected by the Proposed Action:
- Freshwater spawning sites above the USACE dams, with flow regimes, water quality conditions, and substrates well suited to the species’ successful spawning, incubation, and larval development, will continue to be at best marginally accessible to naturally produced UWR Chinook. Spawning habitat below Dexter and Fall Creek dams is accessible to these fish, but this habitat is degraded as a result of ongoing Project operation. Flow releases from Dexter, Lookout Point, and Hills Creek dams continue to create adverse temperature conditions that result in delayed spawning, embryo mortality, and accelerated incubation in the habitat below Dexter. This habitat is also affected by sudden Project shutdowns that can cause extreme ramping of outflows, which reduces the quality of spawning habitat by dewatering redds, reducing egg-to-fry survival. The habitat is further degraded by the Project’s interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, the continued

existence and maintenance of revetments downstream of Dexter Dam prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.

- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portion of the Middle Fork subbasin, below Dexter and Fall Creek dams, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that would otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project Dams may, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Dexter, Lookout Point, and Hills Creek dams and reservoirs. Under current conditions these obstructions preclude reestablishment of a productive naturally spawning UWR Chinook population in the subbasin. Although trap and haul facilities will continue to operate under the Proposed Action, these facilities are outdated and, without modification, do not ensure unobstructed migration corridors. Functional downstream passage conditions for juveniles have yet to be established at any of the USACE dams.

In aggregate, these effects will continue to diminish habitat availability and suitability within the Middle Fork subbasin for juvenile and adult lifestages of UWR Chinook. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting a large, productive, and diverse population.

Table 5.2-5 Effects of the Proposed Action on UWR Chinook salmon population (VSP column) and critical habitat (PCE column) in the Middle Fork Willamette River subbasin. Modified from USACE 2007a, Table 6-4

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Population abundance and productivity, and spatial distribution, have the potential to substantially increase as a result of successfully re-establishing a self-sustaining, naturally produced population of spring Chinook salmon in habitat located upstream of Dexter, Lookout Point, Fall Creek, and Hills Creek dams, but under the Proposed Action, the likelihood of this occurring is low.	Upstream passage will continue to be inadequate unless the Action Agencies firmly commit to rebuild Dexter and Fall Creek traps; downstream passage will continue to kill and injure juvenile fish unless the Action Agencies complete studies and commit to improve survival at the dams to levels comparable to that at other dams in the NW. Fish will continue to lack access to historical habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Dexter Dam would reduce risks to ESA-listed fish species. If water temperature conditions are also improved, the improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring would document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Continue to limit juvenile production from lower Middle Fork Willamette below Dexter, Hills Creek below Hills Cr dam, and Fall Cr below Fall Cr. Dam.	With no firm commitment on when and if temperature control will be carried out, NMFS expects continued temperature effects, significantly reducing juvenile production from lower Middle Fork Willamette below Dexter, Hills Creek below Hills Cr dam, and Fall Cr below Fall Cr. Dam.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ turbidity	No effect.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Flow management at USACE dams within the subbasin will continue to elevate summer flows and dilute pollutants, providing a benefit to ESA-listed salmonids downstream of the dams. The consequences of this particular benefit are likely minor relative to the substantially negative effect that unnaturally warm temperatures below Dexter and Fall Creek dams during fall have on the spawning success and emergence timing of UWR Chinook (see above).	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No change in effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No change in effect. Occasional spills may elevate TDG to levels sufficient to harm UWR Chinook embryos, alevins, and juveniles in the Middle Fork Willamette River below Dexter Dam	No change in effect
Freshwater spawning sites	Habitat Elements	Substrate	Continued lack of new gravels to existing spawning habitat below dams reduces abundance and productivity of UWR Chinook salmon by limiting and degrading available habitat.	Operation of Project dams will continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. .
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the Middle Fork Willamette because holding and rearing habitat below the dams continues to be degraded and is not being replaced.	Operation of Project dams will continue to block transport of large wood from reservoirs to downstream habitat; revetments will continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools...

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat will reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Dexter and Fall Creek dams. Operation of Project dams and continued existence and maintenance of revetments will continue to prevent peak flows, block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-Channel Habitat	Continued lack of off-channel habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat below Dexter and Fall Creek dams. Project operation will continue to reduce peak flows, limiting overbank flows, and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of the Opinion, nor that the operation will connect the main channel to off-channel habitat.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation will continue to reduce peak flows and block large wood and sediment transport, limiting channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Degraded streambanks will inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetment existence and maintenance will continue to prevent streambanks from supporting natural floodplain function in the Middle Fork Willamette below Dexter Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments will continue to prevent overbank flow and side channel connectivity in reaches below Dexter and Fall Creek dams. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat will reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and continued existence and maintenance of revetments will continue to prevent formation of new gravel bars on which riparian vegetation could grow below Dexter and Fall Creek dams. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

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Chapter 5.3
McKenzie River Subbasin Effects

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5.3 McKenzie River Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on the McKenzie population of Chinook salmon would be continued degradation of habitat downstream of Cougar Dam and restricted access to historical habitat, reducing abundance and productivity of this population and adversely modifying critical habitat. The Proposed Action would continue to:
  - Restrict fish access to historical spawning and rearing habitat;
  - Degrade physical habitat downstream from the dam complex;
  - Decrease fitness and productivity of the population due to excessive hatchery stray rates.
- Continued operation of the temperature control tower at Cougar Dam would restore normative water temperatures to downstream fish habitat in the South Fork McKenzie and McKenzie rivers, increasing productivity of those UWR Chinook salmon spawning below the dam.

In the McKenzie River subbasin, the only listed anadromous fish species is UWR Chinook salmon. The McKenzie population is a stronghold population for the ESU and still sustains the highest production of natural-origin spring Chinook salmon in the Willamette Basin. The current abundance however is greatly reduced compared to historical levels and the population is at a "moderate" risk of extinction (McElhany et al. 2007). The primary causes for the decline of this population include loss of access to historical spawning and rearing habitat, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook, and unscreened water diversions (Leaburg-Walterville canals). For a full description of the status of the ESU and Environmental Baseline, see Chapters 3 and 4 above.

Taking into account the environmental baseline and current status of the McKenzie population, described briefly in the preceding paragraph and in detail within section 4.3, below is an assessment of the effects of the Proposed Action in the McKenzie River subbasin.

The Proposed Action includes the following broad on-the-ground actions:

- Current configuration, continued operation, and maintenance of Cougar Dam on the South Fork McKenzie River and Blue River Dam on Blue River, both in the McKenzie River watershed.
- Flow Management- volume and seasonal timing of water released from Cougar and Blue River dams.

- Ramping Rates- efforts by the USACE to limit downramping rates below Cougar and Blue River dams to no greater than 0.1 ft. per hour during nighttime hours and 0.2 ft. per hour rate during daylight hours.
- Hatchery Program- continued production of hatchery Chinook at McKenzie Hatchery for fishery augmentation and conservation purposes.
- Outplanting Program- trap and haul of UWR Chinook from below Cougar Dam to release locations above impassible barriers in the McKenzie, as well as locations below barriers on the McKenzie, to hatcheries for spawning, and other unnamed locations (USACE 2007a, Table 3-16)
- Cougar adult fish collection facilities- operate and maintain a new fish trap at the base of Cougar Dam.[1]

In this section, NMFS considers the effects of the Proposed Action on the McKenzie Chinook salmon population. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of Cougar Dam and restricted access to historical habitat, reducing abundance and productivity of this population. NMFS expects the Proposed Action will result in some improvements in hatchery management, although straying of hatchery fish will continue to be a problem, resulting in further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action will continue to harm individual fish such that the McKenzie Chinook salmon population will continue to decline and critical habitat will continue to be adversely modified as a result of the Proposed Action.

5.3.1 Habitat Access & Fish Passage

Cougar Dam blocked 56 km (Myers et al. 2006, p 55) of spawning habitat historically available to the McKenzie population of UWR Chinook. Blue River Dam blocked 2.7 miles (USACE 2007a). The Action Agencies propose, as an interim measure, to continue to experimentally[2] transport some UWR Chinook above Cougar Dam (USACE 2007a) providing a modicum of upstream passage. Downstream passage of juvenile salmon through the reservoir and dam would continue to occur under the current configuration of the project, but would be problematic in the current downstream configuration. Juvenile salmon would pass through either the turbines or regulating outlet at Cougar Dam, depending on how much water is released and whether turbines are in service. Neither downstream passage route is equipped with a screen or other bypass structures that would allow it to safely pass juvenile fish.

The Action Agencies propose to conduct several studies to evaluate passage mortality over the term of the Opinion. However, no definitive actions are proposed at this time to help improve downstream passage of juvenile salmon beyond baseline conditions of project configurations and operations. Therefore, with respect to habitat access, there would be no improvement over baseline conditions certain.

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[1] Construction of the proposed Cougar Adult Fish Facility was consulted upon separately; however, facility operation is part of this consultation.

[2] USACE 2007a, p. 3-43,48. The Action Agencies state that their Proposed Action is not to be construed as a commitment to permanently restore access to now-blocked historical habitat, but that they will do this to a degree to evaluate *". . . the natural production potential of historic habitat."*

The key proposed actions related to habitat access in the McKenzie River watershed that need to be evaluated for the effects on UWR Chinook salmon are the following:

- Continue to use a portion of the broodstock collected at McKenzie Hatchery for the outplanting program, and truck and haul these fish above Cougar reservoir, and release them in appropriate habitat to spawn.
- In 2010, begin to collect adult fish at the proposed Cougar adult fish collection facility (construction addressed in a separate biological opinion (NMFS 2007a) and use a portion of these fish for the outplanting program.
- Continue to pass juvenile salmon downstream through the Cougar reservoir and dam under current configurations. Flow operations would be as described in the Supplemental BA.
- Conduct the "Willamette System Review Study" that will evaluate downstream passage alternatives at Cougar Dam and reservoir. The actual order in which the McKenzie River would be studied among the other watersheds would be determined in Phases I and II of the study. However, the North Santiam was proposed to be first priority (USACE 2007a).

UWR Chinook salmon access to historical habitat blocked by the dams (particularly in the South Fork McKenzie above Cougar Dam) in the McKenzie River is of critical importance in order to reduce spatial structure risks of the population, increase the habitat area available for reproduction to mitigate for habitat effects downstream of the Projects, and utilize the high quality habitat upstream of the impassable dams.

The following is an assessment of the adult outplanting program, resulting juvenile production, and downstream juvenile fish survival through the reservoirs and dams.

5.3.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Outplanting of adult Chinook salmon above Cougar dam, the lowermost impassable barrier in the watershed, began in the early 1990s (Beidler and Knapp 2005). Of those hatchery Chinook salmon that were transported and released above Cougar Dam, some successfully spawned in the habitat above Cougar Reservoir, and produced juvenile fish, some of which emigrated downstream through Cougar Reservoir and Dam. The outplanting of Chinook above Cougar Dam has been more successful than other outplanting efforts in the basin (Beidler and Knapp 2005; ODFW 2007a). The mortality of adults released above Cougar Dam has been low. The combination of relatively good collection facilities (McKenzie hatchery), good quality adult fish that have not held for an extended period below an impassable dam, short travel time to point of release, and high quality habitat above Cougar Dam in the South Fork McKenzie have all likely contributed to the greater success of the outplanting program here in the McKenzie compared to other areas (Beidler and Knapp 2005). As discussed further below in section 5.3.1.2, a relatively high number of smolts (14,000 fish; Taylor 2000) have been observed below Cougar Dam considering less than 1,000 outplanted fish would have produced these juvenile offspring (Beidler and Knapp 2005).

Construction of a new fish trap at the base of Cougar Dam was described in Baseline section 4.3.3.1.3. NMFS completed a biological opinion on this project (NMFS 2007a), and construction is expected in 2009. Operation of the new Cougar trap would be part of this

Proposed Action. It would allow UWR Chinook salmon, and other fish species, that ascend to the base of Cougar dam to be captured for later truck transport to various dispositions. Willis estimates that about 1300 UWR Chinook will be handled annually by this trap, with 1% mortality and another 1% injured in trapping operations, another 1% mortality in transport operations (Willis 2008). Some trapped fish would be transferred and released above the dam where abundant quality habitat remains. Some fish would likely be taken to hatcheries for artificial spawning, while other, hatchery-origin fish might be returned downstream to allow anglers further opportunities to catch them. Fish could also be returned to the base of Cougar Dam, although the Action Agencies propose this only if other options are precluded. The facility would have several ponds in which to hold and segregate fish to facilitate their later transfer. While fish subjected to handling and trucking always have some risk of being injured or killed, fish at this modern facility would be handled as gently as current technology allows. This fish trap would include a short fish ladder to assist in raising the fish to a level where trapping operations could be conveniently conducted. The ladder could hypothetically be extended in future years to allow fish a means to volitionally pass over Cougar Dam. However, extending the ladder is unlikely due to the 452' height of the dam and the wide range of forebay water surface elevations that would need to be accommodated by a ladder.)

The practice of holding fish in the river below dams (rather than either trapping or passing them immediately) means that adult fish holding below dams have increased likelihood of trying to swim up into turbines, where they may experience severe injuries. Such injuries have been noted at Cougar Dam (Wade 2007). Particularly when turbines are started and stopped, velocities in turbine tailraces are reduced to levels that are within the swimming abilities of UWR Chinook, and they may seek to move upstream through the turbines if no alternatives are presented.

Once constructed, the new Cougar trap, designed as closely to NMFS hydraulic design criteria as possible, would be less stressful to fish than the other existing traps at the base of Project dams. However, even the safest trap facilities and transport operations put stress on fish due to handling, sampling, and delay in passage. NMFS does not consider trap and haul as a preferred method of upstream passage at a dam (NMFS 2008e) and would expect that under the Proposed Action, a small proportion of individual UWR Chinook salmon adults would experience physiological stress during these operations, resulting in increased rates of prespawning mortality compared to fish that are not subjected to trap and haul.

The Chinook outplanting program above Cougar Dam on the South Fork McKenzie has been more successful than in other areas. Even though prespawning mortality of outplanted Chinook is suspected to still be high, spawning of fish in the fall has been consistently observed. The improved collection, handling, and transporting protocols identified in the supplemental BA will likely improve adult survival once fully implemented in the future (ODFW 2007a). There is also concern with the continued outplanting of only hatchery-origin Chinook above Cougar Dam and the risks to the genetic integrity of the McKenzie population as a whole (as described in section 5.3.5.3).

5.3.1.2 Juvenile Production

Between 1998 and 2000 Taylor experimentally introduced adult UWR Chinook above Cougar Dam, which resulted in their subsequent spawning, and juvenile production. Productivity of upstream habitat was not specifically investigated, however, prior to the construction of the dam the area was noted as highly productive and little had changed. The screw traps placed by Taylor below the dam caught 14,000 juvenile UWR Chinook during this period, indicating indirectly that the habitat remains suitable (Taylor 2000.)

5.3.1.3 Reservoir & Dam Survival

Downstream fish passage through Cougar reservoir and dam is causing adverse effects on fry and smolt life stages of UWR Chinook salmon. Juvenile fish must migrate downstream through the reservoirs and pass over or through the dams on their seaward migration. Data on the survival rate of juvenile Chinook through the reservoirs and dams in the McKenzie River is limited. Studies conducted by Taylor between 1998 and 2000 showed that between 81.9% and 92.9% of fish trapped immediately below the Cougar Dam turbines survived, while 67.7% of fish passing through the Regulating Outlet (a non-turbine route) survived (Taylor 2000, p. 4).

5.3.1.4 Willamette System Review Study

The Proposed Action describes a process that will be undertaken for the Willamette Project (all 13 Project dams in the Willamette Basin) to prioritize fish passage needs and improvements. There are five phases to the study that will occur within the next 15 years. Since no specific actions have been identified in the study proposal for the McKenzie River, it is currently unknown what the potential benefits may be to this population in the future from eventual actions that may be carried out as a result of this comprehensive study. NMFS expects that there will be significant benefits to UWR Chinook salmon and UWR steelhead at various tributaries in the Willamette Basin eventually, if the Action Agencies complete the studies and carry out recommended fish passage, water quality, and habitat improvement projects.

Conclusion

The effect of the Proposed Action on habitat access and fish passage in the McKenzie subbasin would be to continue to provide good upstream passage conditions for adult spring Chinook at Cougar Dam on the South Fork McKenzie River, based on operation of the soon-to-be-constructed Cougar trap at the base of the dam. This will continue to provide good spatial distribution for UWR Chinook salmon by ensuring adult fish access to what was once a heavily used spawning area. Downstream passage conditions for the offspring of adults passed above Cougar Dam would remain poor at the dam unless new and effective downstream passage facilities are constructed and operated as an outcome of the Willamette System Review Study. It is uncertain whether or when effective downstream passage conditions would be provided at the dam.

5.3 2 Water Quantity/Hydrograph

Under the environmental baseline, the Action Agencies are attempting to provide streamflow conditions below USACE dams that will support properly functioning habitat for UWR Chinook salmon. These attempts appear successful except that active flood control operations may dewater incubating eggs downstream from Cougar Dam, flood control impairs processes that might otherwise create complex salmonid habitat, and equipment at the dam may be insufficient to keep downramp rates low enough to assure that juvenile fish will not be entrapped or stranded when flows are low (see Section 4.3.3.2). Other water developments, notably EWEB's Leaburg and Walterville developments also have small adverse flow-related effects on UWR Chinook. Increasing population and water demands in the Eugene, Oregon area indicate that flow-related anadromous fish habitat will likely continue to decline in the environmental baseline for the duration of this Opinion.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action would be the same as those described under the environmental baseline for the McKenzie River (Section 4.3.3.2).

5.3.2.1 Seasonal Flows

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge.

The USACE has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.3-1). Failure to meet these flows will affect the South Fork of the McKenzie River to its confluence with the mainstem McKenzie River, about 4 miles, by limiting adult spawning and holding habitat; for juveniles, eggs may be desiccated, barriers to juvenile rearing habitat presented, and opportunities for stranding and entrapment during flow fluctuations enhanced.

Table 5.3-1 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the McKenzie River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Blue River	Sep 1 - Oct 15	Chinook spawning	50	<1%			
	Oct 16 - Jan 31	Chinook incubation[3]	50	<1%			
	Feb 1 - Aug 31	Chinook rearing	50	<1%			

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Cougar	Sep 1 - Oct 15	Chinook spawning	300	<1%	580 Through Sep 30, when possible	40	Sep
	Oct 16 - Jan 31	Chinook incubation[3]	300	<1%			
	Feb 1 - May 31	Chinook rearing	300	<1%			
	Jun 1 - Jun 30	Chinook rearing / adult migration	400	<1%			
	Jul 1 - Jul 31	Chinook rearing	300	<1%			
	Aug 1 - Aug 31	Chinook rearing	300	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

[1] Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

[2] Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

[3] When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the McKenzie subbasin. In general, the lower the frequency that these objectives are not met, the better the conditions for salmon and steelhead survival. Because these flows closely correlate with fish management agency recommendations, the best currently available information, we consider these proposed operations to be highly protective and an improvement over baseline conditions prior to 2000.

The Action Agencies also propose to conduct instream flow compliance and effectiveness monitoring and may also conduct limited experimental operations to determine if the proposed water management operations meet the needs of anadromous fish. As these data become available, NMFS anticipates that water management programs would be modified as necessary to meet anadromous fish needs. Because it is unclear whether such investigations would result in any changes in project operations, we cannot assume any benefit to anadromous fish at this time.

5.3.2.2 Frequency of Channel-forming & Over-bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Cougar and Blue River dams, project operation would continue to limit channel complexity and thereby limit rearing habitat for juvenile UWR Chinook salmon. Peak flow reduction also reduces the recruitment and suitability of channel substrates for spawning salmon and greatly reduces recruitment of large woody debris to areas downstream of the Projects. These effects are expected to continue over the life of the Proposed Action.

On the other hand, reducing peak flows during flood events likely provides some benefits to UWR Chinook salmon by reducing the likelihood that high flows would scour redds and disrupt incubating eggs (compared to the unregulated condition), particularly in the South Fork McKenzie downstream from Cougar Dam.

5.3.2.3 Ramping Rates

The Action Agencies propose to operate the projects to meet a 0.1 ft. per hour downramping rate during nighttime hours and a 0.2 ft. per hour rate during daylight hours whenever existing equipment at their dams will allow, and to investigate the effectiveness of these measures. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992).

The USACE (2007a) has suggested that existing equipment at their dams will be unable to keep downramp rates below the targeted levels when flows approach agreed-upon seasonal minimums. Until further information becomes available, NMFS considers the Action Agency efforts to constrain downramping rates to be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment at moderate to moderately low flows but potentially ineffective at doing so when discharges from the USACE dams approach the minimums. Measures are needed to identify and carry out mechanical, operational, or structural changes that would enable the finer adjustments to meet ramping rates at low flows when they are most needed for fish protection.

5.5.2.4 Water Use

Reclamation has contracted a total of 1,640 acre-feet of water stored in Cougar and Blue River reservoirs to irrigators along the McKenzie River (USACE 2007a). As part of the Proposed Action, Reclamation intends to issue contracts to an additional 100 acre-feet of water stored in USACE's McKenzie River basin projects and has proposed issuing contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[3]

USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the McKenzie River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD.

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[3] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 2% or 190 acre-feet would be issued to serve areas in the South Santiam subbasin.

Assuming that such conditions would occur for only about 60 days each summer, the total level of proposed future Reclamation-supported water use could reduce flows in some sections of the McKenzie River by 15 cfs, an increase of 1 cfs over current use. Because the average flow during July and August at the USGS gaging station near Vida, Oregon (USGS Station Number 14162500) is 2580, this level of project-based water use is unlikely to substantially affect listed species. These effects are expected to continue and worsen over the life of the Proposed Action.

5.5.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management actions. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.3.3 Water Quality

Water temperature and TDG are two important water quality attributes that are affected by operation of the USACE dams in the McKenzie subbasin and that influence natural production of UWR Chinook salmon in habitat downstream of the dams. The Proposed Action would continue operation of Cougar Dam with the temperature control facility in place. The effect of this action would be to continue to provide a more normative thermal regime in the lower South Fork and in the mainstem McKenzie River below the South Fork. This regime is better suited to adult spring Chinook that migrate up the McKenzie and South Fork McKenzie rivers to spawn in these areas and is expected to continue to assure proper embryo development rates and fry emergence timing, resulting in continued survival and productivity of the McKenzie Chinook salmon population. A summary of the effects of the Proposed Action on all water quality attributes is described in Table 5.3-4.

5.3.3.1 Water Temperature

The Action Agencies propose to operate the recently completed Cougar Dam Water Temperature Control (WTC) facility to better meet downstream water temperature requirements of ESA-listed species and to undertake an extended research, monitoring and evaluation (RM&E) program associated with Cougar Dam. Evaluation of the physical and biological effects downstream from the Cougar Dam facility is critical to the decision-process associated with the potential for structural modification of other dams in the system, but will have no effect on salmon in the McKenzie.

Available water temperature monitoring data (see Figure 4.3-6) clearly shows that Cougar Dam, with the new WTC operating, no longer disrupts the natural temperature regime of the South Fork McKenzie River. Results from 2007 suggest water temperatures below Cougar Dam have improved for Chinook spawning and egg incubation compared to water temperatures before the Cougar WTC facility was constructed (Figure 5.3-1). Water temperatures in 2007 below Cougar

Dam were similar (or below) temperature targets established to benefit Chinook salmon production downstream of Cougar Dam (NMFS and USFWS 2000). The cooler fall temperatures, when eggs are developing in the redds, allow juvenile Chinook to emerge in late winter or early spring, increasing their chances of survival compared to the early emergence that occurred prior to completion of the WTC facility. Figure 5.3-2 shows calculations of estimated hatch and emergence timing of juvenile Chinook above (representing normative temperatures) and below Cougar Dam and reservoir (prior to completion of the WTC facility) based on water temperature units.

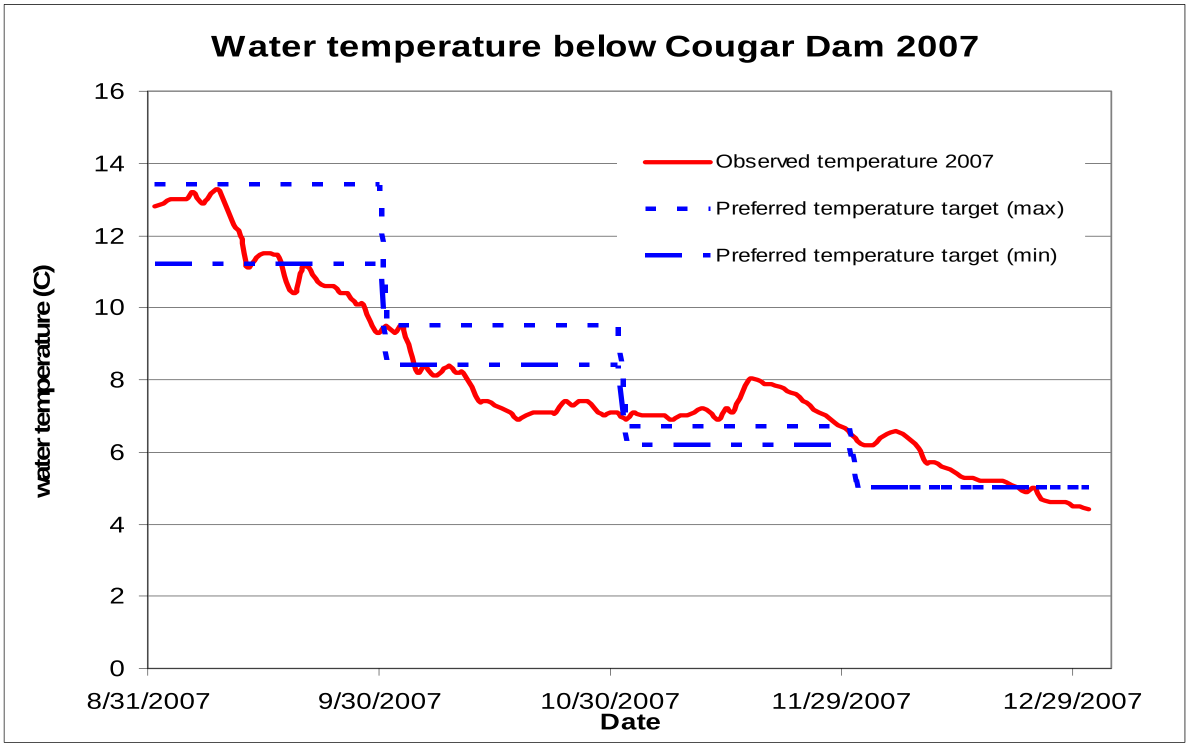

Figure 5.3-1 Comparison of observed and target water temperatures released from Cougar Dam during Chinook spawning and egg incubation in 2007.

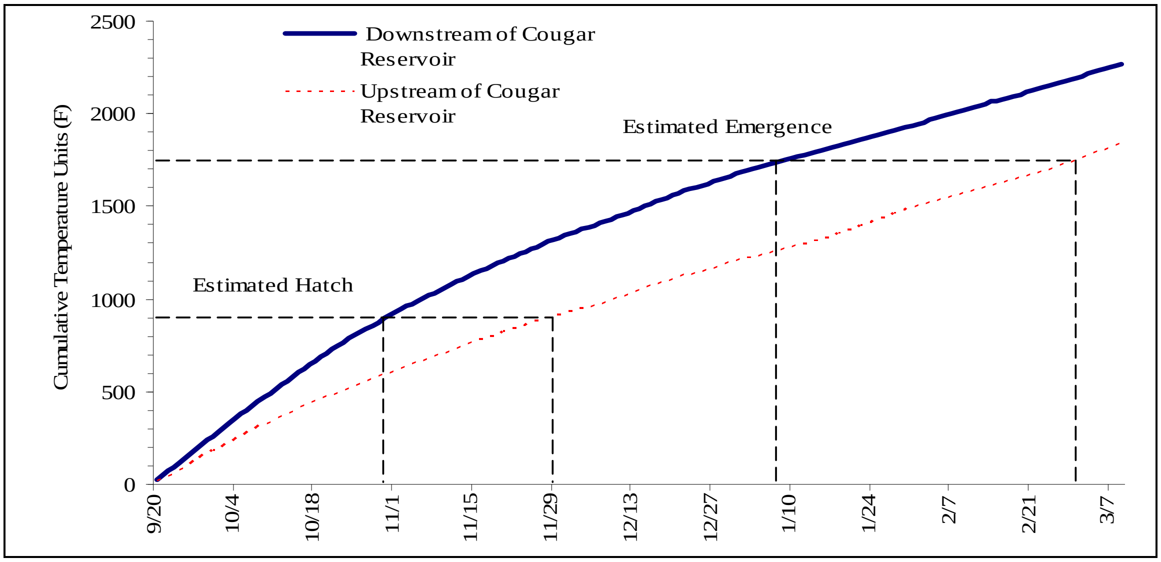

Figure 5.3-2 Estimated hatch and emergence timing of juvenile Chinook above and below Cougar Dam and reservoir, fall 2004 through late-winter 2005, before the WTC was completed. Figure taken from Taylor and Garletts (2007).

The McKenzie Chinook salmon population will likely benefit from this more normative temperature regime below Cougar Dam in terms of more natural upstream adult migration (USACE 2000) and appropriate water temperatures for spawning and egg incubation that leads to increased juvenile production with a more natural emergence timing (ODFW 1985, 1987, 2000). Available data from the Rogue River Basin has demonstrated that spring Chinook production downstream of Lost Creek Dam has benefited significantly from the WTC facility on this dam and the corresponding more normative temperature regime in late summer, fall, and early winter that improved egg survival, emergence timing, and the abundance of juvenile Chinook (ODFW 2000a). NMFS expects similar results will accrue to the natural production area affected downstream of Cougar Dam.

During development of its McKenzie River water temperature control plan, the USACE (1995) recommended the construction of temperature control facilities at both its Cougar and Blue River dams to benefit UWR Chinook salmon reproductive success. The estimated benefit was based on the combined effects of both temperature control projects on McKenzie River water temperatures and temperature-related fish production effects. Both temperature control projects were approved by Congress.

Final design and construction of the new Cougar Dam temperature control intake structure was more expensive than anticipated and the completed project proved to be more effective than had been estimated. Therefore, the likely benefits of the Blue River control structure would be smaller than anticipated.

With the agreement of the fishery agencies (NMFS, USFWS, ODFW), USACE shifted project funds from the Blue River temperature control structure to constructing a new fish trap in the South Fork McKenzie River, downstream from Cougar Dam. The fishery agencies agreed that an adult fish collection facility downstream from Cougar Dam would provide greater benefit to fish management and fish populations than would be provided by completing the Blue River water temperature control project at this time. Consequently, available funds were shifted to final design and construction of a trap and haul facility downstream from Cougar Dam. Construction of a temperature control structure at Blue River Dam was deferred. The Cougar fish trap is scheduled for completion during 2010. The Blue River temperature control structure remains authorized and the Corps could pursue project completion in the future, if warranted.

5.3.3.2 TDG

Supersaturation of dissolved oxygen in the water released below Cougar Dam has also been observed and can be detrimental to spring Chinook eggs and alevins downstream from the dam. In April 2006, USACE tested TDG under increasing spill from the Cougar Dam regulating outlet and turbine discharge ranging from 0 to 530 cfs (Britton 2006). When regulating outlet discharge reached 2000 cfs, TDG exceeded 120% in the South Fork McKenzie just below the confluence of the regulating outlet channel and the tailrace. Because TDG is compensated at greater depths,[4] TDG was estimated at 100% at depths ranging from 0.8 to 2.2 meters. Flows exceeding 2,000 cfs are projected to occur at the following frequency: Oct 0%, Nov 3%, Dec 14%, Jan 20%, Feb 7%, Mar 6%, Apr 0%, May 2%, June 1%, Jul – Sep 0%. NMFS has no information on TDG at Blue River Dam, but would expect spill operations there to cause TDG exceedences there, as well.

No other changes in the water quality conditions and their effects on anadromous fish described for the Environmental Baseline (Chapter 4) are expected in the McKenzie basin.

5.3.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the McKenzie River subbasin that will affect UWR Chinook salmon are the following:

- Continue to operate Cougar Dam, blocking sediment and large wood transport from upstream reaches and tributaries into the South Fork McKenzie River below the dam and much of the mainstem McKenzie River.
- Continue to operate Blue River Dam, blocking sediment and large wood transport from upstream reaches and tributaries into the Blue River below the dam and the lower x miles of the mainstem McKenzie River.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids.
- Continue the existence and maintenance of 4.17 miles of revetments along the lower McKenzie River, preventing channel migration and reducing channel complexity.

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[4] For example, Weitkamp, D.E., and Katz, M. A Review of Dissolved Gas Supersaturation Literature. Transaction of the American Fisheries Society 9:659-702, 1980. This paper notes that depth compensates for supersaturation at an approximate rate of 10%/meter of depth.

- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.

5.3.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the McKenzie River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.3.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.3-4 and described below. Adverse substrate effects on the South Fork McKenzie River extend from Cougar Dam to the confluence with the McKenzie River, about 4.5 miles (Willis 2008), and on Blue River from Blue River Dam to its confluence with the McKenzie River.

Under the Proposed Action, operation of Cougar and Blue River dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the McKenzie subbasin population of UWR Chinook salmon. These effects would be most apparent in the South Fork McKenzie from Cougar Dam at RM 4.4 to its mouth, and in Blue River, from Blue River Dam at RM 1.8 to its mouth. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the McKenzie subbasin.

As described in sections 4.3.3.4, operation of Cougar and Blue River dams has trapped gravel and large wood from 23% of the subbasin and has reduced the magnitude of peak flows. As a result of both the altered hydrologic regime and the dams acting as barriers to sediment transport, fish rearing and spawning habitat below the dams would continue to be degraded by substrate coarsening and the inability to create new gravel bars, islands, and side channels.

Continued existence and maintenance of the USACE revetments would prevent river migration and contribution of sediment from 4.17 miles of streambank in the lower McKenzie, further depriving the river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows will exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

The continued degradation of habitat in the South Fork McKenzie downstream of Cougar Dam and in Blue River downstream of Blue River Dam will likely reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon that can be produced in this presently degraded habitat. Additionally, these dams would also decrease sediment input into the mainstem McKenzie River, but the adverse effects on UWR Chinook would be less dramatic because sediment inputs from other tributaries are expected to continue. Because adults do not have access to historical spawning grounds upstream of Cougar Dam, a reduction in spawning habitat in the reach below Cougar could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Aside from unspecified habitat restoration actions that may result from proposed habitat studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the McKenzie subbasin. Therefore, the effects of the proposed action on substrate, sediment transport, large wood, and channel complexity will continue to be negative for Chinook salmon.

5.3.4.2 Riparian Vegetation & Floodplain Connectivity in the McKenzie River Subbasin

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon (section 4.3.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.3-4 (end of this section 5.3) and described below.

Under the Proposed Action, operation of Cougar and Blue River dams and continued existence and maintenance of 4.17 miles of revetments in the lower McKenzie River will continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work will be done during the term of this Opinion. As noted above in Section 5.3.3, NMFS expects that operation of the water temperature control facility at Cougar Dam will improve conditions for spawning and incubation in the South Fork McKenzie River below the dam. Nonetheless, this limited spawning habitat would continue to degrade under the Proposed Action without habitat restoration efforts aimed at restoring floodplain connectivity and establishing riparian vegetation.

The extent and function of riparian vegetation and floodplains in the McKenzie subbasin will continue to be impaired by Cougar and Blue River dam operations under the Proposed Action. Cougar Reservoir inundated approximately 200 acres of riparian hardwoods in the South Fork McKenzie drainage, while Blue River inundated 975 acres of stream channel, riparian forest, and upland forest in the Blue River drainage. The USACE replaced 11 miles of riparian vegetation with revetments in the lower McKenzie River, and would maintain 4.17 miles of revetments under the Proposed Action.

Flood control operations in the McKenzie River subbasin have probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the Proposed Action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

As described above in section 5.3.4.1, operation of Cougar and Blue River dams would continue to trap gravel and large wood and reduce the magnitude of peak flows in the McKenzie River subbasin. Both of these factors deprive downstream reaches of material and transport mechanisms needed to create new gravel bars and floodplains on which new riparian vegetation can establish. Additionally, USACE revetments will continue to prevent river migration and contribution of sediment from 4.17 miles of streambank along the lower McKenzie, further depriving the river of sediment and the ability to construct new surfaces on which riparian vegetation can establish. The reduced width of riparian forests could prevent shading of the McKenzie River, which could allow summer water temperatures to increase.

In summary, the proposed operation of the Willamette Project will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the McKenzie River subbasin downstream of Cougar and Blue River dams. This limits recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Reduced inundation of forested floodplains reduces nutrient and organic matter exchange during flood events, and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the McKenzie River subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Cougar Dam (see Section 5.3.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will put the McKenzie subbasin population of UWR Chinook salmon at even higher risk of extinction than its current status.

5.3.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock # 23) and summer steelhead (ODFW stock # 24) and release these fish into the McKenzie River at McKenzie and Leaburg Hatcheries. Details about these programs are described in the McKenzie spring Chinook HGMP (ODFW 2007a) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook in the McKenzie River.

5.3.5.1 Hatchery Operations

There are three hatchery-related facilities located within the McKenzie River watershed: 1) McKenzie Hatchery, 2) Leaburg Hatchery, and 3) fish trap at Leaburg Dam. McKenzie Hatchery collects, spawns, incubates, and rears spring Chinook salmon for the McKenzie River hatchery program. Broodstock are collected at this hatchery and also at a trap in the fish ladder at Leaburg Dam when necessary. The Leaburg Hatchery rears and releases resident rainbow trout and summer steelhead into the McKenzie River.

As described above in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section 5.1 above, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook in the McKenzie River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below under their appropriate section (i.e. effects of disease-laden water discharges from a hatchery on listed fish downstream).

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook, summer steelhead, and rainbow trout at McKenzie and Leaburg Hatcheries has been very low over the last several decades and are of no consequence to the conservation and recovery of spring Chinook. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Because there have been few significant mortality accidents at this hatchery in the past, and since the fraction of wild spring Chinook used as hatchery broodstock is low (Table 5.3-2), the risk of facility failure is deemed to be a low risk to wild spring Chinook in the McKenzie population at this time.

The water intake for the McKenzie Hatchery water supply is located on Leaburg Canal (a diversion that starts at Leaburg Dam). This canal was recently screened using NMFS' criteria by the Eugene Water and Electric Board (EWEB). Since the hatchery's water supply is downstream of this screen, there should not be a problem with juvenile Chinook entering or getting impinged on the hatchery intake. Leaburg Hatchery's water intake is located upstream of Leaburg Dam on the McKenzie River. This water intake does not meet NMFS' criteria for listed juvenile salmon. The potential problems associated with this intake should be evaluated and addressed, particularly since EWEB's diversions are now screened adequately.

Table 5.3-2 Composition of spring Chinook salmon without fin clips that were spawned at McKenzie Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. Run of wild fish is estimated from dam count and does not include run of wild fish downstream of Leaburg Dam. Source: McLaughlin et al. (2008)

	Unclipped[a]		Fin-clipped	Percent wild—	
River, year	Wild	Hatchery	hatchery	in broodstock	of run
McKenzie					
2002	13	101	933	1.2	0.4
2003	14	42	953	1.4	0.3
2004	24	105	880	2.4	0.5
2005[b]	20	40	1,022	1.8	0.8
2006	100	46	845	10.1	4.6

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 53 fish (of which 18 were wild).

5.3.5.2 Broodstock Collection

The only broodstock collections that occur in the McKenzie River are for spring Chinook salmon. Summer steelhead broodstock are collected at Foster Dam on the South Santiam and rainbow trout broodstock are raised at Leaburg Hatchery.

Spring Chinook broodstock are collected from volitional returns to McKenzie Hatchery and also at the fish trap at Leaburg Dam. The impacts to the wild population from broodstock collection are minimal. Ever since all returning hatchery fish have been fin-clipped, which allows wild fish to be distinguished from hatchery fish, few wild fish have been observed returning to the McKenzie Hatchery facility. In recent years, 2%-6% of the Chinook entering the hatchery were unclipped (McLaughlin et al. 2008). This equates to a range of 60 to 180 unclipped fish (of which some proportion are undoubtedly hatchery fish that did not get fin-clipped). Since the hatchery stock is an “integrated” stock, where wild fish are purposefully incorporated into the broodstock, all of these unclipped fish have been incorporated into the broodstock. In 2006 and 2007, in an effort to incorporate more wild fish into the broodstock, collections have also occurred at the fish trap on the ladder at Leaburg Dam. The trap is operated and checked daily for a few days during the peak of the wild run in June. Once the desired number of wild fish are collected for broodstock (according to the HGMP broodstock sliding scale), then trapping is discontinued and upstream migration occurs as normal.

5.3.5.3 Genetic Introgression

Genetic introgression of hatchery fish into the wild population in the McKenzie River is of significant concern and is the most critical hatchery issue in this consultation. The McKenzie population is one of two stronghold populations for the entire ESU. The WLCTRT identified this population as a “core” and “genetic legacy” population (Myers et al. 2006). A substantial amount of habitat is still functioning properly in the McKenzie River Basin, as evidenced by the thousands of wild fish that return on an annual basis. This situation is drastically different than in other populations-- like the Middle Fork Willamette or North Santiam-- where few wild fish are being produced and the only source of fish for recovery efforts are found in the abundant hatchery stock. Using hatchery fish in these populations is the only option because there are very low numbers of wild fish.

Before all hatchery fish returns were adipose fin-clipped in 2002, it was presumed that hatchery fish straying above Leaburg Dam was minimal (NMFS 2000a). However, in recent years when all hatchery Chinook returns have been marked, a substantial proportion of the Chinook that migrated upstream of Leaburg Dam were of hatchery-origin. Hatchery fish have comprised up to 36% of the spawners upstream of Leaburg Dam in the core spawning areas for this population as shown in Table 5.3-3 (McLaughlin et al. 2008). In 2005-2006, hatchery fish spawning decreased to 13-16%.

Table 5.3-3 Composition of spring Chinook salmon in the McKenzie subbasin above Leaburg Dam, based on carcasses recovered. Weighted for distribution of redds among survey areas within a watershed. Source: McLaughlin et al. (2008)

Run year	Fin-clipped	Unclipped[a] Hatchery	Unclipped[a] Wild	Percent wild[b]
2001	62	53 (17)	263	70 (69)
2002	140	78 (15)	454	68 (62)
2003	131	60 (15)	333	64 (62)
2004	134	26 (8)	316	66 (60)
2005	32	15 (6)	251	84 (84)
2006	32	4 (2)	247	87 (83)

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution is in parentheses.

There are substantial risks with having hatchery fish interbreeding with the wild population, as described in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above (see section 5.1.5.2.3). The genetic risks are well documented in the literature. Naturally spawning hatchery fish can also confound the evaluation of the health of the wild population because non-natural, hatchery fish are continually spawning in the wild (McElhany et al. 2000). Both of these risks are concerns in the McKenzie population.

Over the last few years, efforts were conducted to remove hatchery Chinook from the ladder at Leaburg Dam in order to reduce hatchery fish spawning in the wild. However, the ladders on Leaburg Dam are not adequate for sorting out hatchery fish without having significant impacts to commingled wild fish. Due to these wild fish concerns, the efforts to remove hatchery fish were discontinued. In order to address the hatchery fish straying issue in the McKenzie River, possible solutions include reducing hatchery production so that fewer hatchery fish return to the McKenzie and thus reduce the number of hatchery fish straying above Leaburg Dam. Another option would be to sort out hatchery fish at Leaburg Dam with an improved facility to automatically sort out hatchery fish with a coded wire tag. Similar automatic sorting facilities are used in other areas such as the Warm Springs Hatchery on the Deschutes River.

There is also concern with using hatchery-origin fish for outplanting efforts above Cougar Dam on the South Fork McKenzie. This risk was described in NMFS and USFWS (2000). Under the Proposed Action, ODFW would continue to outplant substantial numbers of hatchery-origin fish above Cougar Dam. The risk is that progeny of these hatchery fish will be unmarked and indistinguishable upon return from other natural-origin fish. These F1 (first generation naturally spawning) hatchery fish would likely interbreed in the wild population, and thus put more hatchery genes into the wild population. Once the trap is built at Cougar Dam, an alternative to continuing to place hatchery fish from McKenzie Hatchery above Cougar Dam would be to collect Chinook that volitionally return to the South Fork McKenzie and outplant only those fish. It may be important to only outplant natural-origin returns, even though the return may be low (e.g. <100 fish) in order to promote local adaptation within the South Fork subbasin.

5.3.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the McKenzie subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon is unknown. Hatchery fish are released as smolts from McKenzie Hatchery, located in the lower river. Significant juvenile fish rearing occurs in the lower river and in the mainstem Willamette River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in Section 5.10, Mainstem Willamette River.

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the McKenzie River. The risk of hatchery fish spreading diseases in the McKenzie is likely to be lower than in other areas where wild and hatchery fish are all congregated below an impassable dam.

5.3.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to migrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

Adults
No competitive interactions are likely in the adult life stage in the McKenzie River.

5.3.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

5.3.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead are more likely to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These "non-migrants" will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.3.5.8 Fisheries

As discussed in the general effects of hatchery program section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990's. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, it is unusual to catch steelhead of either natural or hatchery origin in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.3.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose fin-clipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during fin-clipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.3.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted above the dams in an effort to restore natural production in historical habitat. This provides benefits to aquatic and terrestrial food chains.

5.3.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS’ (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information can be found in Schroeder et al. (2006).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.3.6 Summary of Effects on the McKenzie Chinook Salmon Population

Table 5.3-4 summarizes anticipated effects of the revised proposed action on VSP parameters for UWR Chinook salmon in the McKenzie River subbasin. In summary, considering the current status of this population, environmental baseline conditions, and the Proposed Action, NMFS is concerned with the viability of this "stronghold" population because its numbers are decreasing and will continue to decrease under the Proposed Action. Loss of historical spawning habitat, impacts to habitat downstream of the Projects, and significant hatchery fish introgression are still impacting this population. The Proposed Action continues to represent substantial impacts to the abundance, productivity, spatial structure, and diversity of the McKenzie Chinook population. These parameters are further described below.

5.3.6.1 Abundance

The impacts of the Proposed Action has and will continue to affect the survival of spring Chinook at both the juvenile and adult life stages in the McKenzie River and thereby affect the abundance of this population. Juvenile Chinook are impacted directly by mortality associated with downstream migration at the Projects and affected indirectly by the degraded habitat conditions downstream of the Projects that reduce habitat quantity and quality and thereby reduce their survival. Adult Chinook are impacted directly by collection of fish for broodstock, mortality associated with outplanting efforts above the dams, and direct mortality as they migrate to the base of the dams. In addition, there is an indirect impact of the Proposed Action from the changes that have occurred to adult migration, holding, and spawning habitats.

5.3.6.2 Productivity

As described above, the problem associated with hatchery Chinook straying and spawning above Leaburg Dam represents substantial risk to the productivity of the McKenzie population over the long term. The best available science shows hatchery influences on wild populations need to be low for a population to be viable. There are risks associated with fitness loss, decreased production, and concerns with knowing whether the McKenzie population is truly viable in the absence of the hatchery fish subsidy that need to be corrected.

5.3.6.3 Spatial Structure

The Proposed Action would continue to prevent Chinook salmon from safely accessing historical habitats above Cougar and Blue River dams. Of particular concern is the loss of habitat above Cougar Dam because historically this area accounted for the most spring Chinook production lost. Restoring production above Cougar Dam, with appropriate survival of adult and juveniles, will increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions.

5.3.6.4 Diversity

Many aspects of the McKenzie population have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there have undoubtedly been changes in the diversity of the McKenzie population. Population traits are now not as diverse as the historical population, which is of concern with fluctuating environmental conditions and the ability of salmon to respond and survive. The habitat changes that have occurred by the Proposed Action downstream of the Projects have affected the population in an unquantifiable manner. The influence of hatchery fish on the wild population also represents risk to the diversity of the natural-origin population.

5.3.7 Effects of the Proposed Action on Designated Critical Habitat

The South Fork McKenzie River above and below Cougar Dam, the Blue River below Blue River Dam, and the mainstem McKenzie River have been designated as critical habitat for UWR Chinook salmon. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.3-2 assesses the anticipated effects of the revised proposed action on PCEs and VSP parameters for UWR Chinook salmon in the McKenzie River subbasin. These effects are attributable to a lack of functional fish passage at Cougar and (to a much lesser extent) Blue River dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the McKenzie, South Fork McKenzie, and Blue rivers, and USACE maintenance of 4.17 miles of revetments along the lower McKenzie River. The following PCEs will be adversely affected by the Proposed Action:

- Except for the outplanting program, freshwater spawning sites above Cougar Dam, with flow regimes, water quality conditions, and substrates well suited to the species' successful spawning, incubation, and larval development, will remain inaccessible to naturally produced UWR Chinook. Spawning habitat in the lower-most South Fork McKenzie (below Cougar) and in the mainstem McKenzie below the South Fork is accessible to these fish, but will continue to be diminished by the Project's interruption of sediment transport, such that new gravels needed for spawning may not fully replace those that move downstream during high flows. Additionally, the continued existence and maintenance of revetments along the lower McKenzie prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created in adjacent areas.
- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portions of the South Fork and mainstem McKenzie, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Cougar Dam when flows are relatively low will continue to pose risks of juvenile stranding and loss in the lower South Fork.
- The historically important migratory corridor along the lower South Fork McKenzie will continue to be obstructed by Cougar Dam and Reservoir. Under the Proposed Action these obstructions are likely to continue to preclude reestablishment of a productive naturally spawning component of the McKenzie's UWR Chinook population in the once highly productive upper South Fork watershed. Adult UWR Chinook will be passed over Cougar Dam as part of the outplanting program and for research purposes, but downstream migrating juveniles will face hazards and delay in Cougar Reservoir as well as at Cougar Dam.

In aggregate, these effects will continue to diminish habitat availability and suitability within the McKenzie subbasin for juvenile and adult lifestages of UWR Chinook. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting a large, productive, and diverse population.

Table 5.3-4 Effects of the Proposed Action on UWR Chinook salmon population (VSP column) and Critical Habitat (PCE column) in the McKenzie River Subbasin. (Modified from USACE 2007a, Table 6-3).

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Population abundance, productivity, and spatial distribution will continue to be impaired under the Proposed Action, which does not commit to providing long-term access to preferred habitat above Cougar Dam; Blue River Dam has similar, but much smaller adverse effects (before inundation, there was a natural fish barrier on Blue River, limiting historical use of upstream habitat.)	Except for research purposes, adult UWR Chinook will be prevented from accessing habitat above Cougar Dam,. Downstream migrating juveniles will face hazards and delay in the Cougar Pool, as well as transiting through Cougar Dam itself.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Cougar Dam could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance may also increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Population abundance and productivity will increase. Habitat quality of the natural production areas in the South Fork and mainstem McKenzie rivers from below Cougar Dam to above Leaburg Dam will improve. Both spawning activity and egg-to-fingerling survival are expected to increase, especially in the South Fork, resulting in improved spatial distribution. Biological monitoring will document realized changes.	Shifts toward a more normal thermal regime in the lower South Fork McKenzie and in the mainstem McKenzie below the South Fork will continue to restore desirable conditions to migration, holding, spawning, incubation, and rearing habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No change in effect.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Productivity above the Cougar Dam may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no effect from our activities.	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No change in effect. High TDG immediately below USACE dams during spill events will continue to have the potential to unfavorably affect early lifestages of UWR Chinook.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	Productivity above the Cougar Dam may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no effect from our activities.	No effect.
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing spawning habitat below Cougar Dam reduces abundance and productivity of UWR Chinook salmon by limiting and degrading available habitat.	Operation of Project dams will continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation will not guarantee that sediment will be placed below Cougar Dam at adequate levels to restore fully functioning habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the McKenzie Subbasin because holding and rearing habitat below the dams continues to be degraded and is not being replaced.	Operation of Project dams will continue to block transport of large wood from reservoirs to downstream habitat, revetments will continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD will not guarantee new LWD will be placed in reaches below the dams.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat will reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Cougar and Blue River dams. Operation of Project dams and continued existence and maintenance of revetments will continue to prevent peak flows, block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Continued lack of off-channel habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the South Fork McKenzie River below Cougar Dam and in the mainstem and lower McKenzie River. Project operation will continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation will occur during the term of this Opinion, nor that the operation will open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions habitat will reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation will continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures will occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks will inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetments will continue to prevent streambanks from supporting natural floodplain function in the mainstem McKenzie River and the South Fork McKenzie River below Cougar Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and revetments will continue to prevent overbank flow and side channel connectivity in the mainstem McKenzie River and the South Fork McKenzie River below Cougar Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat will reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and revetments will continue to prevent formation of new gravel bars on which riparian vegetation could grow below Cougar and Blue River dams and in the mainstem McKenzie River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes will be funded or carried out during the term of this Opinion.

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Calapooia Subbasin
Effects

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5.4 Calapooia Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on Calapooia populations of UWR Chinook salmon and UWR steelhead would be relatively small compared to baseline conditions, but would contribute to continued degradation of habitat along the mainstem Calapooia, causing minor reduction in abundance and productivity of these populations and adversely modifying critical habitat. The Proposed Action would continue to degrade physical habitat elements in the lower Calapooia River

Introduction

For the Calapooia populations of UWR Chinook salmon and UWR steelhead, the Proposed Action includes the following on-the-ground actions:

- Revetments - Continue the existence and maintenance of 0.17 miles of revetments along the Calapooia River
- Studies - Additionally, the Proposed Action includes a study of the effects of revetments on downstream habitat and possible habitat restoration projects in the Willamette basin projects to restore habitat, if authorized and funding becomes available.

In this section, NMFS considers the effects of the Proposed Action on the Calapooia UWR Chinook salmon and UWR steelhead populations. In general, NMFS expects that the Proposed Action would cause minor increments of continued degradation of habitat due to ongoing existence and maintenance of revetments, resulting in small reductions in abundance and productivity of these populations. NMFS expects the Proposed Action would have no effect on genetic diversity of these populations because there are no hatchery management actions that would affect these populations. NMFS concludes that the Proposed Action would continue to harm a few individual fish such that the Calapooia UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would continue to be adversely modified as a result of the Proposed Action (see Table 5.4-1).

5.4.1 Habitat Access & Fish Passage

The Proposed Action would have minimal effect on habitat access and fish passage, except to the extent that continued existence and maintenance of revetments precludes fish access to side channels and complex habitat. (See section 5.4.4 below).

5.4.2 Water Quantity/Hydrograph

The Proposed Action would have not affect water quantity or the baseline hydrograph in the Calapooia subbasin.

5.4.3 Water Quality

The Proposed Action would have a very small effect on the baseline water quality conditions as a result of continued existence and maintenance of 0.17 miles of revetments in the lower Calapooia River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, existence and maintenance of revetments would result in small increases in summer water temperatures, particularly in the lower part of the Calapooia watershed.

5.4.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Calapooia River subbasin that would affect UWR Chinook salmon and UWR steelhead include the following:

- Continue the existence and maintenance of 0.17 miles of revetments along the Calapooia River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.4.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity in the Calapooia River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.4.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.4-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 0.17 miles of revetments in the lower Calapooia River. Although this length comprises a small percentage of the total revetments and length of this stream, this action would continue to have very small adverse effects by restricting channel migration and preventing recruitment of large wood and sediment from streambanks, both of which inhibit natural processes that create and maintain channel complexity. As described in the Calapooia Baseline section 4.4.6, the middle and lower reaches of the Calapooia River are more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Calapooia populations of UWR Chinook salmon and UWR steelhead.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration of habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Calapooia subbasin.

In summary, although the revetments maintained by the Action Agencies in the Calapooia subbasin are a small percentage of total river length, they contribute to continued degradation of habitat and would likely cause minimal reduction in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment mitigation measures, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Calapooia subbasin.

5.4.4.2 Riparian Vegetation & Floodplain Connectivity in the Calapooia River

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.4.6). NMFS expects that conditions would not improve, and could degrade further under the Proposed Action, as shown in Table 5.4-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 0.17 miles of revetments in the lower Calapooia River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to restrict overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Calapooia subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Calapooia subbasin, would continue to degrade this already impaired habitat, reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Calapooia populations of UWR Chinook salmon and UWR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Calapooia River subbasin during the term of this Opinion.

Conclusion

The proposed continued existence and maintenance of revetments in the Calapooia River would be a small factor in the continued degradation of riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat

Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Calapooia River subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a small reduction in the abundance and productivity of Calapooia subbasin populations of UWR Chinook salmon and UWR steelhead.

5.4.5 Hatcheries

There are no proposed actions related to hatchery programs in the Calapooia subbasin. As described in Section 4.4.4, hatchery fish are no longer released in the Calapooia at any life stage.

5.4.6 Summary of Effects on UWR Chinook Salmon & UWR Steelhead Populations in the Calapooia River Subbasin

Table 5.4-1 summarizes anticipated effects of the Proposed Action on the status of the Calapooia populations of Chinook salmon and steelhead relative to the four VPS parameters.

5.4.6.1 Abundance

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.2 Productivity

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.3 Spatial Structure

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.6.4 Diversity

The Proposed Action would have no measurable effect within the Calapooia subbasin.

5.4.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Calapooia River and many of its tributaries have been designated as Critical Habitat for UWR Chinook salmon and steelhead. Table 5.4-1 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects are attributable to the Action Agencies' continued existence and maintenance of 0.17 miles of revetments along the mainstem Calapooia.

The USACE revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent unfavorable temperature increases) and contribute LWD. Across all of the areas affected within the Calapooia subbasin and elsewhere, the Action Agencies' continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.4-1 Effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations (VSP column) and critical habitat (PCE column) in the Calapooia River subbasin

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor effect of elevated water temperatures could decrease survival and/or growth of juvenile UWR Chinook salmon and steelhead and increase prespawning mortality of adult Chinook and steelhead.	Minor effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, that contribute to elevated summer water temperatures, particularly in the lower part of the Calapooia watershed.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat Elements	Substrate	Very small effect of Proposed Action on substrate in the Calapooia that prevents formation of new gravels, but lower Calapooia not historically used for spawning, and thus effect is mainly to reduce invertebrate productivity on which rearing fish feed. Minimal reduction in abundance and productivity of Calapooia populations of UWR Chinook salmon and UWR steelhead due to small length of revetment in Calapooia.	Continued existence and maintenance of 0.17 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause small reduction in abundance and productivity of UWR Chinook salmon in the Calapooia subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 0.17 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Calapooia River.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued low frequency of pools in lower Calapooia River. Continued existence and maintenance of 0.17 miles of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-Channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would contribute to continued reduced off-channel habitat in the lower Calapooia River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead	Continued existence and maintenance of 0.17 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Calapooia River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Calapooia River during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Calapooia River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, further limiting juvenile rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Calapooia populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 0.17 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Calapooia River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Calapooia subbasin.

Section 5.5
South Santiam Subbasin Effects

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5.5 South Santiam Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on South Santiam populations of UWR Chinook salmon and UWR steelhead would be to continue to reduce abundance, productivity, spatial distribution, and diversity of these populations and to adversely modify critical habitat. The primary effects would include:
  - Continued prevention of fish access to historic habitat above Project dams
  - Continued degradation of water quality and physical habitat elements downstream from Project dams
  - Continued loss of floodplain connectivity and off-channel habitat due to continued existence and maintenance of 1.82 miles of revetments
  - Continued risks and potential benefits associated with the South Santiam Hatchery Chinook and steelhead programs
  - Continued loss of streamflow through the Reclamation irrigation water contract program.

In the South Santiam subbasin, the population of winter steelhead is currently at “moderate” risk of extinction and the spring Chinook are currently at “very high” risk. The abundance of steelhead and Chinook is much reduced compared to historical levels. The primary causes of the decline for these populations include loss of access to historical spawning and rearing habitat above Foster and Green Peter Dams, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook and steelhead, and degraded habitat conditions associated with land management in the tributaries downstream of Foster Dam (ODFW 2007b). For a full description of the status of the ESU and Environmental Baseline, see Chapters 3 and 4 above.

In general, the Proposed Action includes the following actions:

- Current configuration, continued operation, and maintenance of Foster and Green Peter dams in the South Santiam watershed.
- Flow Management- volume and seasonal timing of water released downstream from Foster and Green Peter dams.
- Ramping Rates- targets would be intended to limit down-ramp rates below Foster and Green Peter dams to no greater than 0.1 ft/hr at night and to no greater than 0.2 ft/hr during the daytime.

- Revetments – continued existence and maintenance of 1.82 miles of revetments
- Hatchery Program- continued production of hatchery Chinook for fishery augmentation and conservation purposes; and continued production of summer steelhead for fishery augmentation
- Outplanting Program- trap and haul of UWR Chinook and UWR steelhead from below Foster dam to release locations above and below Foster dam.
- Continued operation of the Foster dam adult fish collection facilities, including possibly rebuilding the facility in the future, date uncertain, contingent on securing funding.

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations in the South Santiam subbasin. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams and continued lack of access to historical habitat, reducing abundance and productivity of these populations. NMFS expects the Proposed Action would result in some improvements in hatchery management, preventing further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action would continue to harm individual fish such that the North Santiam UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would be adversely modified as a result of the Proposed Action (see Table 5.5-3 at the end of this section 5.5).

5.5.1 Habitat Access & Fish Passage

Under the Proposed Action, Foster and Green Peter dams would continue to block UWR Chinook salmon and UWR steelhead from volitional access to historical spawning habitat above Foster Dam in the South Santiam watershed. An existing, but outmoded, fish trap would continue to be operated at the base of Foster Dam, providing a modicum of upstream passage for UWR steelhead, and for UWR Chinook salmon as part of an experimental program. Downstream passage of juvenile salmon and steelhead through Foster reservoir and dam would continue to occur to some degree under the current configuration of the project, but would remain problematic. Though the Action Agencies propose to conduct studies to evaluate passage conditions over the term of the Opinion, no definitive actions are proposed to improve upstream and downstream fish passage beyond the baseline conditions of current project configurations and operations.

The key Proposed Actions related to habitat access in the South Santiam watershed that need to be evaluated for the effects on UWR Chinook salmon and UWR steelhead access and fish passage are the following:

- Continue to operate Foster and Green Peter dams, thereby continuing to block adult UWR Chinook salmon and UWR steelhead from accessing historical habitat above the dams.
- Continue to operate (and possibly rebuild) a fish trap at the base of Foster Dam:

- Continue to collect UWR Chinook salmon, taking some fish to the South Santiam Hatchery and releasing a portion of adult hatchery-origin returning fish into habitat above Foster reservoir.

- Continue to collect UWR steelhead, and truck all of them to release location above Foster Reservoir.

- Continue to pass juvenile salmon downstream (progeny of those adults transported above Foster Dam) through Foster Reservoir and Dam under current configuration and flow operations.
- Conduct the Willamette System Review Study, described earlier, that will evaluate, among other things, upstream and downstream passage at Big Cliff and Detroit dams, and may result in experimental fish introductions in various locations, including UWR steelhead into or above Detroit Reservoir.
- Continue and increase the Action Agency water contract program for irrigation diversions, increasing the potential for fish entrainment at water diversions

The following is an assessment of the effects of conducting adult upstream passage via the existing trucked transport program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.5.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Under the baseline, Foster and Green Peter dams block access to spawning and rearing habitat in the upper South Santiam subbasin, an area that historically produced steelhead and an estimated 85% of the spring Chinook in the South Santiam River (Mattson 1948). Beidler and Knapp (2005) reported that the subbasin above Foster produced a run of about 1400 adult Chinook salmon prior to dam construction. Buchanan et al. (1993) noted that this same area produced about 2600 steelhead prior to dam construction, with about 60 to 70% coming from the Middle Santiam River above the current site of Green Peter Reservoir.

As noted in the description of baseline conditions given in Section 4.5.3.1, both Green Peter and Foster dams originally incorporated upstream and downstream fish passage provisions, though results were disappointing. Buchanan et al. (1993) found that only 46% of adult UWR steelhead natal to upstream of Green Peter Reservoir successfully migrated through Foster Dam to the trap at the base of Green Peter Dam, possibly due to trap attraction problems. Additionally, juvenile downstream migrants were lost in Green Peter Reservoir, presumably due to high levels of predation. Based on these results, the USACE and ODFW terminated all efforts to place UWR Chinook and UWR steelhead above that dam in 1988 (USACE 2000). Adult Chinook passage above Foster was also discontinued due to problems with fallback, but was resumed after 1996 via truck transport.

The Action Agencies propose, as an interim measure (until permanent passage measures are operational), to experimentally[1] trap and transport some hatchery UWR Chinook salmon (and all

[1] USACE 2007a. The Action Agencies state that their Proposed Action is not to be construed as a commitment to permanently restore access to now-blocked historical habitat, but that they will do this to a degree to evaluate *". . . the natural production potential of historic habitat."*

winter steelhead)[2] above Foster Dam (USACE 2007a). As noted in Section 4.5.3.1, winter steelhead have been continuously placed above Foster Dam since construction, although these fish experience fallback rates of up to 4% (USACE 2007a). No fish would be released above Green Peter Dam, due to the observed high rate of loss in Green Peter reservoir.

The Action Agencies proposed to trap fish at the base of Foster Dam and to handle them as described in Table 5.5-1.

Table 5.5-1 Proposed Disposition of Fish Collected at the Foster Fish Facility (Excerpt from USACE 2007a, Table 3-13).

Species	Destination	Target # of Adult Fish *		Maximum % of Wild Run
		Clipped	Unclipped	
Spring Chinook	Broodstock	600	300	30*
	South Santiam above Foster Dam (Riverbend and Gordon Road release sites)	As needed to meet unclipped goal	800 (in excess of broodstock collection goal of 4,000 females)	10
	Recycled into South Santiam below Foster Dam		None	0
	Crabtree, Thomas, and Wiley creeks	Any excess (approx. 100 to Crabtree; 150 to Thomas)	None	0
Winter Steelhead	South Santiam above Foster Dam	0	All	100
	Remove from system	All	0	0
Summer Steelhead	Broodstock	1,700	0	N/A
	Recycling below Foster	Any excess to brood	0	N/A
	Remove from system	Excess to brood and recycling	All	N/A

*These numbers reflect management targets, and are not intended to provide annual on-the-ground direction to personnel operating the fish facilities.

5.5.1.2 Juvenile Production

Beidler and Knapp (2005) report that overall production of Chinook salmon from fish outplanted above Foster Reservoir is relatively low, as compared to the North Santiam above Detroit Reservoir. Based on snorkel surveys above Foster reservoir from 1999 through 2004, ODFW found that juvenile production varies from year to year, and does not correlate with number of adults released in the previous year. Beidler and Knapp recommend smolt trapping below the dams and at the head of Foster reservoir to determine juvenile production from the outplanting program and to assess fish mortality through the dams and reservoirs. They were unable to

[2] All winter steelhead in the subbasin are of natural origin.

explain the variable and low productivity from this habitat, but indicated that high prespawning mortality of hatchery outplants might be the cause of low juvenile production. Given that habitat above these dams historically produced 85% of the South Santiam Chinook salmon run, and that this habitat generally remains in good condition, NMFS would expect that juvenile production would not be a limiting factor if measures were taken to reduce adult fish prespawning mortality rates.

5.5.1.3 Dam & Reservoir Survival

Foster and Green Peter dams were originally equipped with facilities intended for upstream and downstream fish passage, but they never worked well and are considered outmoded by current standards (Beidler and Knapp 2005). Direct mortality of downstream migrating Chinook is 83% past Green Peter Dam and 8-10% past Foster Dam and is assumed to be the same for juvenile steelhead (Willis 2008). Passage routes available to downstream migrating fish at Foster are 1) through unscreened turbines, 2) through other outlets, and 3) over the spillways, during infrequent periods when water is spilled. The Action Agencies propose to continue the spring spill operation at Foster Dam (92 to 238 cfs spill, depending on reservoir elevation and inflow), from April 15 to May 15, to facilitate downstream passage of juvenile and kelt steelhead and juvenile Chinook salmon. This operation is based on a study by Buchanan et al. (1993) that concluded that steelhead smolts could be passed safely at Foster Dam if reservoir elevations were reduced and 300 cfs was released as surface spill. The Proposed Action does not include other measures, beyond studies, to improve reservoir and dam survival at Foster Dam.

Existing egress routes at Green Peter are 1) though unscreened turbines, 2) through other outlets, 3) over the spillways, during infrequent periods when water is spilled, and 4) through existing fish horns that are known to be problematic. As noted above in section 5.5.1.1, fish passage at Green Peter Dam was terminated in 1988, after studies indicated problems with both upstream passage of adult fish and downstream passage of juvenile fish through the reservoir and dam. In 1968 soon after dam construction, over 50,000 UWR steelhead smolts were noted at the Green Peter downstream fish bypass evaluator, but this number declined to 1400 smolts in 1987 and 1988 (Buchanan et al. 1993), likely due to the reservoir creating habitat conducive to predators, including pike minnows and bass. The Proposed Action does not include any measures to consider passage at Green Peter Dam.

The Proposed Action describes a process that will be undertaken for the Willamette Project to prioritize fish passage needs and improvements. However, the Action Agencies state that they cannot make a firm commitment to construct any fish passage facilities or carry out operations indicated by the study because of uncertainty with obtaining authorization and funding. Other than studies, no specific actions are identified that would improve downstream fish passage through Project dams and reservoirs in the South Santiam subbasin.

Conclusion

The effects of the Proposed Action would not improve access for UWR Chinook salmon and UWR steelhead to their historical habitat above Foster and Green Peter dams, and would not increase survival of juveniles traveling downstream through the reservoirs and past the dams.

5.5.2 Water Quality/Hydrology

5.5.2.1 Seasonal Flows

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action are the same as those described under the environmental baseline for the South Santiam River (Section 4.5).

The USACE has estimated the frequency with which it anticipates not meeting the minimum and maximum flows under its proposed operations (Table 5.5-2). When these flows are not met adverse effects – reduced access to spawning habitat and reduced adult holding habitat – occur downstream 37.7 miles to the confluence with the N. Santiam River. Also, the effectiveness of spawning habitat can be reduced if flows are reduced post-spawning, exposing redds and desiccating eggs.

Table 5.5-2 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from projects in the South Santiam River. Source: Donner 2008. Minimum and Maximum Tributary Flow Objectives below Willamette Dams.

Dam	Period	Primary Use	Minimum Flow (cfs)[1]	Chance of Not Meeting Flow	Maximum Flow (cfs)[2]	Chance Of Not Meeting Max Flow and Period of Miss	
Foster	Sep 1 - Oct 15	Chinook Spawning	1,500	25%	3,000 through Sep 30, When Possible	0% 2%	Sep Oct 1-15
	Oct 16 - Jan 31	Chinook incubation	1,100 [1]	20%			
	Feb 1 - Mar 15	Steelhead and Chinook rearing	800	5%			
	Mar 16 - May 15	Steelhead spawning	1,500	20%	3000	30%	Mar 16 - May 15
	May 16 - Jun 30	Steelhead incubation	1,100 [1]	5%			
	Jul 1 - Aug 31	Chinook and steelhead rearing	800	1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

[1] Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

[2] Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

The USACE's reservoir drafting priority schedule (Table 2-6 in Chapter 2, Proposed Action) creates sub-optimal water resource management from the perspective of maintaining desirable tributary flows as high flows and high reservoir drafting rates in other tributaries are required to offset low draft rates from priority reservoirs, principally Detroit reservoir. Tributaries downstream from such low priority reservoirs then tend to have higher flows than needed to support anadromous fish needs during the summer flow augmentation season and may then have insufficient stored water to meet fall flow objectives This effect is not fully defined but is likely most severe during below average water years when drafting demands are highest.

Green Peter and Foster project operations would continue to reduce the flows in the lower South Santiam River during late winter and spring (compared to historical levels) while the reservoirs are being refilled. During this period, juveniles of both species are rearing, smoltifying, and migrating through the Willamette River system to the Pacific Ocean. UWR Chinook fry are emerging from the gravels and winter steelhead are spawning in the South Santiam River downstream from Foster Dam. This flow reduction effect of the Proposed Action may have its largest biological effect on emigrating juvenile spring Chinook and winter steelhead. Reductions in spring flows may also interfere with recruitment of age-0 rainbow trout (*O. mykiss*) (Mitro et al. 2003). Winter flow reductions associated with active flood control operations may dewater Chinook salmon redds, reducing egg survival. These effects are expected to continue over the life of the Proposed Action.

These proposed operations do not provide properly functioning habitat for UWR Chinook salmon and UWR steelhead. Of particular concern is the relatively low probability of meeting the UWR Chinook spawning and rearing objectives in late summer and fall and the difficulty of meeting the maximum flow objectives for steelhead spawning.

5.5.2.2 Foster Dam Spring Spill

The Action Agencies would continue spring spill operation at Foster Dam. Under this operation, approximately 92 to 238 cfs (0.5 to 1.5 feet of water depth), depending upon reservoir elevation and inflow, would be spilled daily from 0600 through 2100 hours from April 15 through May 15 each year to facilitate passage of juvenile and kelt winter steelhead and juvenile spring Chinook salmon that may be passing from the reservoir near its surface.

5.5.2.3 Frequency of Channel-Forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Foster Dam, project operations would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon and steelhead (Section 4.5.3.2). Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon and steelhead. The USACE does not propose any actions to investigate or reduce these effects. These effects are expected to continue and may worsen over the life of the Proposed Action.

Reduction of peak flows in ongoing flood control operations could continue to benefit spring Chinook salmon by reducing the likelihood that high flows would scour and disrupt incubating redds (compared to the unregulated condition). However, the rate at which flows are reduced during flood control operations is also a factor (see below).

5.5.2.4 Flow Fluctuations

The Action Agencies propose to operate Foster and Green Peter dams in an effort to meet an 0.1 ft. per hour downramping rate restriction during nighttime hours and an 0.2 ft. per hour rate restriction during daylight hours, when possible. These rates are derived from available literature on protective ramping rates compiled by Hunter (1992). Based on the best available information, NMFS assumes that meeting this commitment would be sufficient to minimize the adverse effects of rapid discharge fluctuations on stranding and entrapment of juvenile salmonids downstream of the dams as long as existing equipment at the dams allows the USACE to operate within the proposed restrictions. However, the Action Agencies have indicated that the USACE will be unable to meet these ramp rate restrictions during periods when flow releases approach proposed minimums (USACE 2007a). Therefore the proposed protections of juveniles against rapid flow changes may be inadequate to prevent losses. Results of studies that the Action Agencies have proposed for evaluating the effectiveness of their efforts to control ramp rates below Project dams will address this issue and may indicate a need for improved ramp rate controls.

5.5.2.5 Water Contracting

Reclamation has contracted a total of 1,096 acre-feet of water stored in Green Peter and Foster reservoirs to irrigators along the South Santiam River (USACE 2007a), which constitutes a small fraction of the surface water withdrawals issued by OWRD. Another 1,485 acre-feet are contracted to users downstream from the confluence of the North and South Santiam rivers served by USACE reservoirs in both drainages. As part of the Proposed Action, Reclamation intends to issue a contract to an additional 350 acre-feet of water stored in USACE's Santiam River basin projects (primarily Green Peter and Detroit) and has proposed to issue contracts for delivery of up to an additional 10,000 acre-feet of water throughout the Willamette basin.[3]

USACE intends to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Santiam River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD.

Assuming that such conditions would occur for only about 60 days each summer, the total level of proposed future Reclamation-supported water use could reduce flows in some sections of the South Santiam River by 11 cfs and in the Santiam River mainstem by about 25 cfs, an increase of 5 cfs over current use. Because the minimum flow downstream from Foster Dam would be 400 cfs during the late summer, this level of project-based water use is unlikely to substantially

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[3] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 2% or 190 acre-feet would be issued to serve areas in the South Santiam subbasin.

affect listed species during most years. During very low water years, flow reductions associated with existing and new water use could limit juvenile UWR Chinook and winter steelhead rearing habitat during the late summer and thus reduce survival. During the late summer, the USACE operates the Willamette Project to augment Willamette River flows as needed to maintain Albany and Salem minimum flows. To the extent that water stored in Green Peter reservoir is used to meet those targets, low flow conditions in the South Santiam River, including those caused by the Proposed Action, would be mitigated. These effects are expected to continue and worsen over the life of the Proposed Action.

5.5.2.6 Flow-related Research, Monitoring and Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management actions. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.5.3 Water Quality

Under the environmental baseline, certain aspects of water quality do not provide properly functioning habitat for UWR Chinook and UWR steelhead. These aspects include unnaturally warm water in the South Santiam River downstream of Foster Dam during the spawning and early incubation period for spring Chinook as well as high total dissolved gas concentrations in the river below the dam during spill events. Under the Proposed Action these conditions would not improve, and could further degrade.

5.5.3.1 Water Temperature

Water temperature conditions downstream from Foster Dam currently limit the abundance, productivity, and life history diversity (i.e., spawning, incubation, and emergence timing) of UWR Chinook salmon and UWR steelhead in the South Santiam below Foster Dam and in the mainstem Santiam River (see Section 4.5.3.3.). As will be elaborated upon later in this section, lower temperatures than normal below Foster Dam cause pre-spawner straying and mortality; elevated temperatures cause reduced egg viability and increased susceptibility to disease. These adverse effects extend the confluence with the North Santiam River, to 37.7 miles (Willis 2008).

Beginning in the late 1960s, state and federal fisheries managers began to express concerns that changes in the thermal regimes downstream from the large Willamette Project dams in the McKenzie and Santiam watersheds were adversely affecting salmon and steelhead. Following Congressional authorization in 1981, the USACE produced the first in a series of reports responding to these concerns (USACE 1982); and in 1984, the USACE initiated the Willamette System Temperature Control Study. That study produced two primary products: a Santiam sub-basin report (USACE 1988); and a McKenzie sub-basin report (USACE 1987). The Santiam sub-basin report determined that modifying the intake tower at Green Peter Dam and constructing a multilevel release system that drew water from different elevations in the reservoir could restore the natural seasonal water temperature hydrograph to the South Santiam River downstream from Foster Dam.

The majority of the current spawning of Chinook salmon is confined to the area just downstream of Foster Dam (Schroeder et al. 2006). One of the key limiting factors identified for Chinook salmon is the adverse effects associated with altered water temperatures released from Foster Dam, particularly during spawning and egg incubation (see Environmental Baseline Chapter for more details). High mortality of eggs and alevins has been observed in other populations where higher than normal (pre-Project) water temperatures have likely exceeded the temperature limits of Chinook eggs and alevins (see Middle Fork, North Santiam, and McKenzie results in the effects section). The preferred water temperature for spawning and egg incubation is reported in the literature to be in the range 5.0-14.4 C for Chinook in general (Bell 1986; Meehan and Bjornn1991). Significant mortality occurs when eggs are exposed to temperatures outside of this range (Murray and McPhail 1988). Water temperatures downstream of the Projects typically exceed these thresholds for at least a period of time during egg incubation and likely results in high egg mortality in Chinook below Foster Dam (Figure 5.5-1).

There is also concern that even if the eggs survive the warmer than normal temperature regime, the higher temperatures lead to increased development and growth and Chinook emerge from the gravel earlier than normal which also has been shown to decrease juvenile survival (Beacham and Murray 1990; USACE 2000). Data on emergence timing in the North Santiam, McKenzie, and Middle Fork populations below Project dams indicates that Chinoook emergence below dams can occur 8-10 weeks earlier than emergence in a normal temperature regime (see Effects Sections for this discussion). Similar earlier emergence timing is likely to occur with Chinook juveniles below Foster Dam in the South Santiam River due to the elevated temperature regime (Figure 5.5-1). The effect of this earlier emergence timing on Chinook is to cause them to emerge in the winter instead of in the spring. Winter conditions are considerably less suitable and production of food organisms is less, adversely influencing survival of the young fish. Significant mortality is likely (USACE 2000, p. 6-35.) In addition, higher flows in the winter also lead to poorer survival (USACE 2000, p. 6-46).

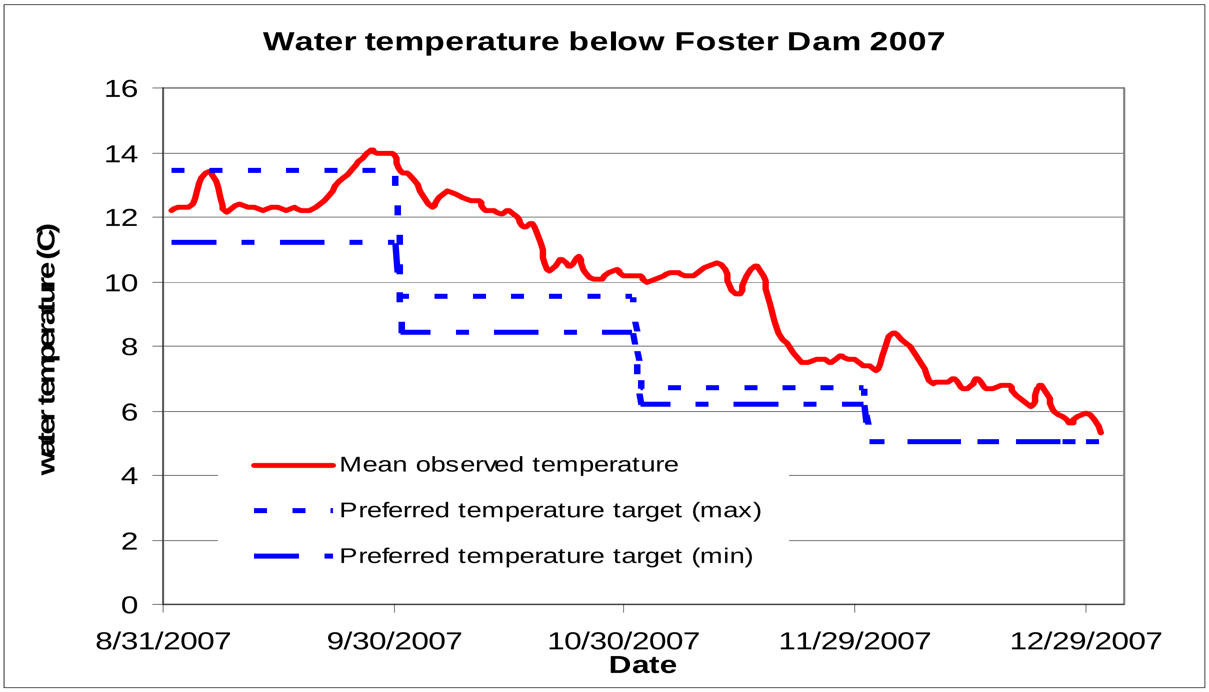

Figure 5.5-1 Comparison of observed and preferred temperature target range (using McKenzie River temperature targets: NMFS, FWS, ODFW 1984.) during spring Chinook spawning and egg incubation.

The Action Agencies have not proposed to modify the intake tower at Foster Dam. However, they propose to further evaluate temperature control at dams without such facilities under the proposed Willamette System Review Study. The goal of this study, which will be completed in three phases, "would be to recommend for implementation those measures shown to be technically feasible, biologically justified, and cost-effective" (USACE 2007a). Completion of these studies would likely require at least 4 years with final design and implementation likely to take another 4 years.

Thus, under the Proposed Action, correction of adverse water temperature conditions in the South Santiam would not be guaranteed. These conditions would continue to adversely affect UWR Chinook and UWR steelhead by causing juveniles to emerge in less favorable conditions, namely during earlier higher flow periods with scarcer forage.

5.5.3.2 TDG

The Proposed Action would maintain the current dam configurations in which spill operations create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae for a one mile (Willis 2008) downstream from Foster Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these South Santiam subbasin populations. The Action Agencies have not proposed to investigate total dissolved gas concentrations below Foster Dam, where Monk et al. (1975) observed TDG concentrations greater than 120% saturation during spills. The proposed operations would continue to minimize the frequency of spill operations but cannot entirely prevent them. Spill occurs primarily during high flow events during winter months, affecting UWR Chinook salmon in redds, but spill also occurs infrequently in other months when emergency events cause powerhouse shutdowns. The Proposed Action does not include any measures to develop emergency bypass valves or protocols using existing facilities to moderate sudden increases in TDG or to quickly address potential effects on UWR Chinook salmon and UWR steelhead downstream from Foster Dam.

Spill over 1,400 cfs at Foster generates more than 115% TDG below foster dam. The expected frequency of this occurrence varies as follows: Oct 0%, Nov 29%, Dec 54%, Jan 65%, Feb 25%, Mar 28%, Apr 13 %, May 4%, June 5% Jul-Sep 0% (Willis 2008). NMFS has no information on TDG below Green Peter Dam, but would expect enhanced TDG during spill there, as well.

5.5.3.3 Summary

Under the environmental baseline, operations at Foster and Green Peter dams have adversely affected the water temperatures in habitat in the lower Middle and South Santiam rivers used by all life stages of UWR Chinook salmon and by juvenile UWR steelhead. A Willamette System Review Study will study these effects. However, because the USACE has not proposed to install a water temperature control system, or to seek appropriations and authorization from Congress, implementation is highly uncertain. Another water quality issue that is directly related to project operations, total dissolved gas, would not be addressed under the Proposed Action and could degrade habitat even further.

5.5.4 Physical Habitat Quality

The key Proposed Actions related to physical habitat quality in the South Santiam River subbasin that will affect UWR Chinook salmon and UWR steelhead are listed below.

- Continue to operate Foster and Green Peter dams, blocking sediment and large wood transport from upstream reaches and tributaries into the South Santiam River below Foster Dam.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 1.82 miles of revetments along the South Santiam River, preventing channel migration and reducing channel complexity.
- Study the potential for gravel augmentation and large wood restoration projects in the South Santiam subbasin to improve salmonid habitat.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, including gravel augmentation, if authorized and funding becomes available.

5.5.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded, and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.5.3.4). This effect occurs continually and extends to the confluence of the N. Santiam River, 37.7 miles downstream from Foster Dam, as well as the short reach between Green Peter Dam and the upper extent of the Foster Reservoir pool. NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.5-5 and described below.

Under the Proposed Action, operation of Foster and Green Peter dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the South Santiam subbasin populations of UWR Chinook salmon and UWR steelhead. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the South Santiam subbasin.

Operation of Green Peter and Foster dams has trapped gravel and large wood from 50% of the subbasin and has reduced the magnitude of peak flows, as described above in Section 4.5.3.4. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, and side channels, which are necessary components of rearing and spawning habitat for both UWR Chinook salmon and UWR steelhead. The only large tributaries that enter the South Santiam downstream of Foster Dam are Crabtree and Thomas creeks, but they join the South Santiam River near its confluence with the North Santiam and do not replenish the most depleted reach just downstream of Foster Dam. Small tributaries to this reach, such as Wiley Creek, cannot contribute sufficient sediment and large wood to compensate for the loss in upstream supply.

The continued existence and maintenance of 1.82 miles of revetments by the USACE would prevent river migration and contribution of sediment from this length of streambank along the lower South Santiam River, further depriving the lower river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

In summary, the continued degradation of habitat in the South Santiam subbasin downstream of Foster and Green Peter dams would likely further reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. It is likely that areas of spawning gravel in the lower river would continue to be replaced with coarse bed material unsuitable for spawning, and that rearing habitat in the form of alcoves and side channels would continue to be reduced as well. Because these populations do not have safe passage and access to historical habitat upstream of the two dams, a reduction in spawning habitat in the reach below Foster could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Additionally, a lack of complex rearing and refugia habitat lower South Santiam River could limit juvenile outmigrant production in the subbasin. Aside from unspecified habitat restoration actions that may result from proposed habitat, revetment, and gravel studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the South Santiam subbasin.

5.5.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (section 4.5.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.5-5 and described below.

Under the Proposed Action, operation of Foster and Green Peter dams and continued existence and maintenance of 1.82 miles of revetments in the lower South Santiam River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the South Santiam River below Foster Dam associated with Project operations (as described in Section 5.5.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in Section 5.5.1 Habitat Access/Fish Passage), further degradation of riparian vegetation and floodplain connectivity would result in a net reduction in the already limited habitat available to UWR Chinook salmon and UWR steelhead in the South Santiam subbasin.

The extent and composition of riparian vegetation in the South Santiam subbasin would continue to be impaired by Foster and Green Peter dam operations under the Proposed Action by interfering with the processes needed for new floodplain forests to establish. Green Peter and Foster dams would continue to trap sediment and large wood and reduce the magnitude of peak flows in the South Santiam River, as described above in section 5.5.4.1. Additionally, the continued existence and maintenance of 1.82 miles of revetments in the lower South Santiam River would further prevent river migration and contribution of sediment and large wood from streambanks of the Santiam River. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. The reduced width and continuity of riparian forests could prevent the shading of the South Santiam River, rendering the river susceptible to increased water temperatures.

In summary, the proposed operation of Foster and Green Peter dams and continued existence and maintenance of revetments along the mainstem Santiam River will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the South Santiam subbasin downstream of Foster and Green Peter dams. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Sup BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the South Santiam subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Foster and Green Peter dams (see Section 5.5.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will reduce the abundance and productivity of South Santiam subbasin populations of UWR Chinook salmon and UWR steelhead.

5.5.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock 024) and summer steelhead (ODFW stock 024), and release these fish into the South Santiam River at Foster Dam. Details about these programs are described in the South Santiam spring Chinook HGMP (ODFW 2008b) and Willamette Basin summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook and winter steelhead in the South Santiam River.

5.5.5.1 Hatchery Operations

There is one hatchery in the South Santiam watershed, South Santiam Hatchery, located at the base of Foster Dam on the South Santiam River. South Santiam Hatchery collects, spawns, incubates, and raises spring Chinook salmon and summer steelhead for the South Santiam Chinook program and the entire Willamette Basin summer steelhead program. Broodstock are collected at the fish ladder on Foster Dam and, to some extent, as volitional returns to the hatchery across the river.

There are two primary concerns with the effects of hatchery facilities on listed spring Chinook and winter steelhead in the South Santiam River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of natural-origin fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish, as described in section 5.1, the “General effects of hatchery programs on ESA-listed salmon”. Other potential adverse of effects of the facilities or related activities are addressed below.

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook and summer steelhead at South Santiam Hatchery has been very low over the last several decades and of no consequence to the conservation and recovery of spring Chinook or winter steelhead. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Since there have been few significant mortality accidents at this hatchery in the past, the risk of facility failure is deemed to be a low risk to natural-origin spring Chinook and winter steelhead in the South Santiam populations.

The water intake for the South Santiam Hatchery water supply is in Foster Reservoir. There are two pipes located on Foster Dam that draw water to the hatchery year round. This water intake does not meet NMFS' criteria for listed juvenile salmon and steelhead. However, given the poor survival of outplanted spring Chinook above Foster Dam, there is a low risk that spring Chinook would be impacted by the water intake of the hatchery at Foster Dam. In contrast, winter steelhead are passed upstream of Foster Dam and juvenile production does occur. It is unknown how emigrating winter steelhead may be impacted by the intake on the dam. Generally, steelhead migrate near the surface of the reservoir and pass over the spillway at Foster Dam. Further evaluation should occur to ascertain the degree of risk the water intake affords to juvenile winter steelhead, especially when juvenile passage through the spillway and turbines of Foster Dam are taken into account.

5.5.5.2 Broodstock Collection

Broodstock collections for the South Santiam spring Chinook program (ODFW 2008b) and Willamette Basin summer steelhead program (ODFW 2004a) both occur at Foster Dam/South Santiam Hatchery. The Supplemental BA and HGMPs specify the specific collection schedules. Approximately 5,500 Chinook are handled annually. Of these, 1% are injured, and less than 1% are killed at the trap. During subsequent trucking operations approximately 1500 fish are transferred to the hatchery or release sites upstream and downstream of Foster Dam, with a mortality of 1% (Willis 2008).

For UWR steelhead, approximately 600 fish are handled; 2% of these are injured and 1% die during trapping operations. Another 1% fail to survive subsequent trucking operations. (Willis 2008)

The effects of hatchery broodstock collection at the Foster Dam trap on UWR Chinook salmon and UWR steelhead from these hatchery programs are likely to be substantial. The trapping situation at Foster Dam is different than any other situation in the Willamette Basin. Listed winter steelhead have been trapped and hauled at Foster Dam for the last few decades in an effort to conserve the winter steelhead run above Foster Dam (impassable barrier). The late run timing of winter steelhead overlaps with the first arrivals of spring Chinook and summer steelhead in April and May. Consequently, it is common to handle winter steelhead that will be outplanted above Foster reservoir, hatchery and natural-origin Chinook, and hatchery summer steelhead at the same time. Early arriving hatchery Chinook and summer steelhead are typically taken back downriver and released in the lower South Santiam so that they are available for harvest in recreational fisheries. All of these collections occur at a trapping facility that was not built for proper handling of natural-origin fish (e.g., crowding in small areas, no water-to-water transfer of fish) nor the high numbers of fish that typically return.

There are few alternatives available for further reducing the effects of this trapping on natural-origin winter steelhead and spring Chinook; besides rebuilding the existing facility. The Foster Dam trap has to be operated from April through May in order to collect wild winter steelhead for transport above the dam. Spring Chinook and summer steelhead that are present will also enter the trap because the fish are actively migrating upstream. Even if the Chinook and summer steelhead hatchery programs were eliminated (which is not an option due to mitigation responsibilities), the problem would still exist but to a lesser degree because hatchery fish would not overwhelm the trap.

5.5.5.3 Genetic Introgression

Spring Chinook

Significant genetic introgression from hatchery fish into the natural population in the South Santiam has occurred since Foster and Green Peter Dams were constructed and this mitigation hatchery program was initiated. Ever since all returning hatchery fish have been mass marked (adipose fin-clipped) so that they could be distinguished from naturally-produced fish in 2002, most of the return has been fish of hatchery-origin (see Figure 4.5-2). In addition, the majority of the fish spawning naturally below Foster Dam have been hatchery fish (Table 5.5-3). The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 9% to 21% from 2002-2006. Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock has been very low (see Table 5.5-4). Thus the PNI values for this population have been very low since 2002—indicating hatchery fish are dominating genetic processes in this population (see Figure 5.2-3).

Table 5.5-3 Composition of spring Chinook salmon in the South Santiam River from Foster to Waterloo, based on carcasses recovered. Weighted for distribution of redds among survey areas. Source: McLaughlin et al. (2008).

	Fin-	Unclipped[a]		Percent
Run year	**clipped**	**Hatchery**	**Wild**	**wild[b]**
2002	1,604	37 (14)	224	12 (12)
2003	970	31 (17)	151	13 (13)
2004	838	30 (26)	85	9 (9)
2005	467	12 (9)	128	21 (20)
2006	243	9 (15)	50	17 (16)

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[b] Percentage not weighted for redd distribution is in parentheses.

Table 5.5-4. Composition of spring Chinook salmon without fin clips that were spawned at South Santiam Hatchery, based on the presence or absence of thermal marks in otoliths, 2002–2006. Source: McLaughlin et al. (2008).

	Unclipped[a]		Fin-clipped	Percent wild—	
Year	Wild	Hatchery	hatchery	in broodstock	of run
2002	26	19	1,174	2.1	---
2003	25	23	1,048	2.3	---
2004	78	16	905	7.8	---
2005[b]	71	19	999	6.5	---
2006[c]	137	46	957	12.0	---

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 63 fish (50 wild).
[c] Otoliths were collected on 152 unclipped fish, of which 114 were wild and 38 were of hatchery origin.

The effect of managing gene flow between the hatchery program and the natural-origin population in the South Santiam River is difficult to discern with the available data. If there were high numbers of natural-origin fish, it would be important to protect and conserve these genetic resources (e.g. like managing hatchery strays in the McKenzie River). However, if there are key limiting factors that prohibit natural production in the natural-origin by hatchery or natural-origin fish (e.g. Middle Fork Willamette), it would first be necessary to correct these key limiting factors and then possibly use the hatchery program for supplementation purposes (Nickum et al. 2004). Prior to the mass marking of hatchery fish, it was believed the natural-origin population was extinct in the South Santiam (Nicholas 1995). However, in recent years a modest number of unmarked Chinook have been collected at the Foster trap and observed in spawning surveys downstream (McLaughlin et al. 2008). However, the trend in natural-origin Chinook returns from 2002 to 2007 has clearly been declining (based upon the number of unmarked fish collected at Foster trap) from a high of 1,457 in 2004 to the most recent low of 131 in 2007 (Schroeder et al. 2006; McLaughlin et al. 2008). Since most of the spawning below Foster Dam has been of fish from hatchery-origin (see Table 5.5-3), it is likely a large proportion of the unmarked adult Chinook returning in recent years are progeny of hatchery spawners.

The modest return of unmarked Chinook back to Foster Dam in certain years from 2002-2007 suggests conditions can be favorable for natural production of spring Chinook in the South Santiam River. It may be that juvenile Chinook production is occurring in the South Santiam River on a regular basis, but when ocean conditions are favorable, survival is greater and more natural-origin Chinook return to the South Santiam (2004 was a good return year with more favorable ocean conditions than experienced by the 2007 adult return).

As more data becomes available on the status of natural production in the South Santiam population of spring Chinook salmon, the management of hatchery Chinook on the spawning grounds below Foster Dam may need to be modified. Actions to reduce the proportion of hatchery fish spawners in the natural-origin may need to be taken in the future in order to reduce genetic risks to acceptable levels. The long-term vision for hatchery management in the South Santiam is to increase natural-origin Chinook production to a level where hatchery mitigation can be reduced and hatchery fish on the spawning grounds above and below Foster Dam are managed for the long-term sustainability of natural-origin fish (see "General effects of hatchery programs on ESA-listed salmon and steelhead" section above for further explanation).

Winter Steelhead

There are no hatchery winter steelhead programs in the South Santiam River. However, hatchery summer steelhead spawn naturally in the same areas as winter steelhead (Schroeder et al. 2006). Since there is some overlap in the spawn timing of summer- and winter-run fish from February through March, the potential exists for summer steelhead to interbreed with winter steelhead in the South Santiam River. However, the likelihood of this occurrence is low. Most of the summer steelhead spawning occurs in January and February (Schroeder et al. 2006). The peak of the listed winter steelhead run over Willamette Falls (downstream of the South Santiam) occurs from late February through March (Myers et al. 2006). Actual spawn timing of these winter steelhead would be weeks later in the tributaries of the South Santiam River.

The primary concerns with the hatchery summer steelhead program are predation and competition, which are addressed below.

5.5.5.4 Disease

Hatchery fish can be agents for the spread of disease to natural-origin fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to natural-origin fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles

In the South Santiam subbasin, the risk of hatchery fish spreading disease to natural-origin juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from South Santiam Hatchery. Significant juvenile fish rearing occurs in the lower river and in the mainstem Santiam River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section "Mainstem Willamette River".

Adults

The potential also exists for returning hatchery fish to spread diseases to natural-origin adult fish commingled in the South Santiam River. The risk of hatchery fish spreading diseases in the South Santiam may be substantial since Chinook congregate at the base of Foster Dam throughout the summer until spawning time in September and October. There is no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.5.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and natural-origin fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles

Since all hatchery fish are released as smolts and are expected to migrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

As described in the "genetic introgression" above, hatchery summer steelhead spawn naturally in winter steelhead habitat. Summer steelhead spawning has been widespread; with the number of spawners positively correlated with run strength (Schroeder et al. 2006). It is likely that progeny from these summer steelhead would negatively affect listed juvenile winter steelhead rearing in their natal habitat. It is unknown whether there is in fact a competitive interaction due to limited resources. However, any interaction between non-native summer steelhead and listed winter steelhead would be undesirable. Juvenile summer steelhead would have a competitive advantage because these fish would hatch earlier and be of larger size than winter steelhead. Monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are the progeny of summer steelhead.

Adults

Given the problem of crowding of adult Chinook at the base of Foster Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.5.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring natural-origin fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon natural-origin steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead (that are the progeny of naturally spawning summer steelhead in winter steelhead habitat) could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are the progeny of summer steelhead.

5.5.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively migrate to the ocean; thus minimizing the potential interaction between hatchery and natural-origin fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may migrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead are more likely to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on natural-origin winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any finclipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on natural-origin steelhead and spring Chinook.

5.5.5.8 Fisheries

As discussed in the “General effects of hatchery programs on ESA-listed salmon and steelhead” section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990’s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historical harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, it is unusual to catch steelhead of either natural or hatchery origin in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.5.5.9 Masking

The production of unmarked hatchery fish can have an impact on natural-origin fish if these hatchery fish stray and intermingle with natural-origin populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the natural-origin population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases, McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.5.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted above the dams in an effort to restore natural production in historical habitats. This provides benefits to aquatic and terrestrial food chains.

5.5.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is found in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on natural-origin populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.5.6 Summary of Effects on the South Santiam Populations of Chinook Salmon & Steelhead

Table 5.4-5 summarizes anticipated effects of the Proposed Action on the VSP parameters for South Santiam populations of Chinook salmon and steelhead.

5.5.6.1 Abundance

There have been substantial impacts of the Proposed Action on UWR Chinook salmon and UWR steelhead in the South Santiam subbasins. The Proposed Action is essentially status quo management of the Projects and thus the abundance of these species is likely to continue decreasing. This is of concern particularly for Chinook since their abundance is low and their trend is clearly declining.

5.5.6.2 Productivity

Productivity of UWR Chinook salmon and steelhead in the South Santiam has been declining over the long- and short- terms. The recent decline in Chinook abundance is of particular concern because productivity has not been increasing. The current hatchery programs represent risks to the listed populations. However, the recent returns of natural-origin Chinook are likely the offspring of hatchery spawners. Thus, production is so poor in this population that hatchery supplementation has to be relied upon until other limiting factors are corrected. Even though this is a high risk scenario, alternatives are limited due to the poor status of natural-origin Chinook. Without substantial improvements to the habitat conditions below Foster Dam and adequate passage of fish above Foster Dam into historical habitats, NMFS expects the productivity and capacity of these populations to reproduce naturally will not improve but will remain at a very low level. There is also concern with the productivity of the steelhead population, particularly for the remnant run that is trapped and hauled above Foster Dam. The productivity of this segment of the population is also declining. The Proposed Action lacks certainty that any improvements would be carried out during the term of this Opinion.

5.5.6.3 Spatial Structure

The Proposed Action continues to limit UWR Chinook salmon and UWR steelhead access to historical habitats above Foster and Green Peter dams. Access is dependent upon trap and haul at Foster Dam. Success of the outplanting program has been mixed. Steelhead outplanting has been successful. Chinook efforts have been poor with high prespawning mortality rates in outplanted fish. Restoring production above Foster Dam, with appropriate survival of adult and juveniles, is needed to increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions. However, the Proposed Action would not provide safe upstream and downstream passage.

5.5.6.4 Diversity

Many aspects of the South Santiam Chinook and steelhead populations have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there has undoubtedly been changes in the diversity of the Chinook and steelhead in the South Santiam. Population traits are now not as diverse as they were in historical populations, and this decreases the ability of salmon and steelhead to respond and survive in response to fluctuating environmental conditions. The Proposed Action would be expected to continue to degrade habitat downstream of Project dams, resulting in more uniform channel characteristics that would select for less diverse life history patterns in the remaining natural-origin Chinook salmon and steelhead. The influence of hatchery fish on the natural-origin population also represents risk to the diversity of the natural-origin population.

5.5.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem South Santiam and a number of its tributaries have been designated as critical habitat for UWR Chinook salmon and UWR steelhead. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.5-5 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower South Santiam River, and continued existence and maintenance of 1.82 miles of revetments along the lower river. The following PCEs will be adversely affected by the Proposed Action:

- Freshwater spawning sites above Foster Dam with flow regimes, water quality conditions, and substrates well suited to the successful spawning, incubation, and larval development of UWR Chinook and UWR steelhead will be marginally accessible to these fish and such sites above Green Peter Dam will remain inaccessible. Spawning habitat will remain accessible to these fish below Foster, but much of this habitat is degraded as a result of ongoing Project operation. Flow releases from Green Peter and Foster dams during late summer and fall will continue to create suboptimal temperature conditions for UWR Chinook that spawn, incubate, and emerge as fry in the habitat below Foster. This habitat is further degraded by the Project's interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, continued existence and maintenance of revetments downstream of Foster Dam prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.
- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook will remain limited and degraded in the fully accessible portion of the mainstem South Santiam River, below Foster, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments, contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project dams will, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Foster and Green Peter dams and reservoirs. Under current conditions these obstructions diminish the abundance and productivity of an above-dam component of naturally produced UWR steelhead and preclude reestablishment of a productive naturally spawning UWR Chinook population in the upper South Santiam subbasin.

In aggregate, these effects will continue to diminish habitat availability and suitability within the South Santiam subbasin for juvenile and adult lifestages of UWR Chinook and UWR steelhead. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting large, productive, and diverse populations of these fish.

Table 5.5-5 Effects of the Proposed Action on Chinook Salmon and Steelhead Populations (VSP column) and Critical Habitat (PCE column) in the South Santiam subbasin. Modified USACE 2007a, Table 6-2.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat Access	Physical Barriers	Proposed Action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Foster Dam, and prevent access above Green Peter Dam.	Proposed Action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Foster Dam, and prevent access above Green Peter Dam.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Foster Dam will reduce risks to ESA-listed fish species. The improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook and UWR steelhead will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel-forming processes that help create or maintain channel complexity will continue.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Initially, no change in effect from existing suboptimal conditions for spawning, incubation, and emergence of UWR Chinook. If and when WTC capability is developed and implemented, population abundance and productivity would increase. Habitat quality in the natural production area below Foster would improve. Spawning activity and egg-to-fingerling survival is expected to increase for UWR Chinook, resulting in the potential for improved abundance and productivity. Biological monitoring would document realized changes.	Unfavorable thermal conditions below Foster Dam during fall will continue into the future unless the Action Agencies develop WTC capability.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect.	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical contamination /Nutrients	Productivity above the Green Peter/Foster project may increase to an unknown extent as a result of increased levels of marine derived nutrients. At this time, the Action Agencies make a conservative assumption of no improvement in effect from our activities.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	Continued augmentation of summer flows will continue to help overcome historical water quality problems in the river below Lebanon.	Continuing minor positive effect on the quality of rearing/migration habitat provided in the lower-most South Santiam River.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	Spill operations would continue to create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae for a short distance downstream from Foster Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these South Santiam subbasin populations.	Continued unfavorable effect during spill events on spawning/early rearing habitat immediately below Foster Dam.
Freshwater spawning sites	Habitat Elements	Substrate	Continued lack of new gravels to existing spawning habitat below Foster Dam would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available habitat.	Operation of Foster and Green Peter dams would continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation would not guarantee that sediment would be placed below Foster Dam at adequate levels to restore fully functioning habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon in the South Santiam Subbasin because holding and rearing habitat below the dams would continue to degrade and would not be replaced.	Operation of Project dams would continue to block transport of large wood from reservoirs to downstream habitat, revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD would not guarantee new LWD will be placed in reaches below the dams.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat would reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality below Foster Dam. Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the South Santiam River below Foster Dam. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks would inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and revetments would continue to prevent streambanks from supporting natural floodplain function in the lower South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and revetments would continue to prevent overbank flow and side channel connectivity in the South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the South Santiam River below Foster Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Section 5.6
North Santiam Subbasin Effects

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5.6 North Santiam Subbasin: Effects of the Willamette Project Proposed Action on UWR Chinook Salmon & UWR Steelhead & Critical Habitat

Summary of the Effects of the Proposed Action

- The effects of the Proposed Action on North Santiam populations of UWR Chinook salmon and UWR steelhead would be substantially the same as NMFS determined in its baseline analysis, that Chinook and steelhead ESUs would continue to decline and critical habitat would continue to be adversely modified. The Proposed Action would continue to:
  - prevent fish access to historical spawning and rearing habitat
  - degrade water quality and physical habitat elements downstream from the dam complex
  - reduce streamflow through the Reclamation irrigation water contract program
  - create risks and potential benefits associated with the North Santiam Hatchery Chinook and steelhead programs

Introduction

The North Santiam River subbasin supports a population of UWR steelhead and also one of UWR Chinook salmon. The population of winter steelhead is currently at “moderate” risk of extinction. Spring Chinook are currently at “very high” risk of extinction. The abundance of steelhead and Chinook is currently much reduced compared to historic levels. The primary causes of the decline for these populations include loss of access to historical spawning and rearing habitat above Big Cliff and Detroit Dams, altered physical and biological conditions downstream of the dams (hydrograph, temperature, flow, recruitment of gravel and woody debris), interbreeding between hatchery and natural-origin Chinook and steelhead, and degraded habitat conditions associated with land management in the tributaries downstream of Big Cliff Dam (ODFW 2007b). For a full description of the status of the ESU and environmental baseline, see Chapters 3 and 4.

The Proposed Action includes the following broad actions:

- Project dams: continued operation and maintenance under existing configuration of Big Cliff and Detroit dams in the North Santiam subbasin.
  - Flow Management- targets for volume and seasonal timing of water released downstream from Big Cliff and Detroit dams.
  - Ramping Rates- targets that control how quickly water releases from Big Cliff and Detroit dams are increased or decreased, with the intent of limiting maximum nighttime downramp rates to 0.1 ft/hr and maximum daytime downramp rates to 0.2 ft/hr.

- Hatchery Program- continued production of hatchery Chinook and summer steelhead for fishery augmentation and conservation purposes; continued operation of Marion Forks Hatchery.
- Outplanting Program- trap and haul of Chinook from below Big Cliff and Detroit dams to release locations above the dams.
- Continue to operate (currently at Minto) adult fish collection facilities- possibly rebuild facility in the future, date uncertain and based on funding.
- Continued existence and maintenance of 3.87 miles of revetments
- Withdrawal and consumptive use of stream water will be facilitated through a contract water sales program

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations in the North Santiam subbasin. In general, NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams and continued lack of access to historical habitat, reducing abundance and productivity of these populations. NMFS expects the Proposed Action would result in some improvements in hatchery management, preventing further decline in genetic diversity from baseline conditions. NMFS concludes that the Proposed Action would continue to harm individual fish such that the North Santiam UWR Chinook salmon and UWR steelhead populations would continue to decline and critical habitat would continue to be adversely modified as a result of the Proposed Action. (See Table 5.6-4 at the end of this section)

5.6.1 Habitat Access & Fish Passage

Under the Proposed Action, Big Cliff and Detroit dams would continue to block access to and from UWR Chinook salmon and UWR steelhead spawning habitat in the North Santiam subbasin above these dams, as described in the baseline. As described in the North Santiam Baseline Section 4.6.3.1, UWR Chinook salmon access to habitat blocked by the dams in the North Santiam subbasin remains of critical importance because the remaining spawning habitat below the dams would continue to degrade under the Proposed Action, reducing abundance and productivity.

The key proposed actions related to habitat access in the North Santiam watershed that need to be evaluated for the effects on UWR Chinook salmon and UWR steelhead are the following:

- Continue to operate Big Cliff and Detroit dams, thereby continuing to block adult UWR Chinook salmon and UWR steelhead from accessing historic habitat above the dams.
- Continue to operate (and possibly rebuild or relocate) a fish trap (with associated dam that blocks passage) which is currently located at Minto (below Big Cliff and Detroit Dams),
    - Continue to collect UWR Chinook salmon at this trap, taking some fish to the Marion Forks Hatchery and releasing a portion of adult hatchery-origin returning fish into habitat above Detroit reservoir and below Big Cliff reservoir.

- Continue to collect UWR steelhead at this fish trap. These trapped non-hatchery origin UWR steelhead are released above the Minto trap, in the reach below Big Cliff Dam, where there remains some spawning opportunity.

- Continue to pass juvenile salmon downstream (progeny of those adults transported above the Detroit/Big Cliff complex) through the reservoirs and dams under current configurations.

- Conduct the Willamette System Review Study described earlier, that will evaluate, among other things, upstream and downstream passage at Big Cliff and Detroit dams, and may result in experimental fish introductions in various locations, including UWR steelhead into or above Detroit Reservoir.

The following is an assessment of adult upstream passage via the outplanting program, resulting juvenile production, and downstream juvenile fish passage through the reservoirs and dams.

5.6.1.1 Upstream Passage/Potential Utilization of Blocked Habitat

Since the early 1990s, ODFW has been collecting UWR Chinook salmon and UWR steelhead at the Minto trap and releasing all of the UWR steelhead above Minto Dam and a portion of UWR Chinook hatchery fish only above Detroit reservoir, as described in the Baseline Section 4.6.2. A primary objective of this program was to determine the feasibility of using hatchery adult salmon to restore viable populations of Chinook salmon above barriers and in other waters where native spring Chinook populations have been essentially extirpated (Beidler and Knapp 2005).

The Proposed Action calls for continued operation of the Minto trap. Fish trapped at Minto would be either:

- released immediately upstream where they may utilize the 2 mile reach between Minto Dam and Big Cliff Dam, and where they will have some opportunity to spawn and complete their life cycles;

- Transported (hatchery-origin UWR Chinook only) to release points above Detroit Reservoir;

- transported via trucks to other streams, such as the Little North Fork, where they may be able to complete their life-cycles.

- Some of the excess marked (hatchery-origin) UWR Chinook are “recycled”—trucked downstream and released to increase angling opportunities.

- Some are spawned (killed, their eggs taken, for hatchery production)

- All UWR (winter) steelhead are released upstream of Minto dam.

- Summer (non-native) steelhead are removed from the system.

Under the Proposed Action, UWR Chinook and UWR steelhead would continue to be injured, stressed, and infrequently killed (about 4% of Chinook and 1% of steelhead handled, with another 1% of each species killed during transport) as a result of continued operation of the Minto Trap. As described in the Baseline Section 4.6.3.1, the Minto Trap is outdated and is not designed to collect and hold salmon and steelhead for later release into streams for natural spawning. Although the Action Agencies propose to rebuild the Minto Trap, if funding and authorization is provided, there is no certainty that this action will be accomplished during the term of this Opinion. The Action Agencies have proposed to use new, improved transport and release protocols as part of the outplanting program, which would be expected to reduce fish stress and injury during transport, but without improved adult release sites, NMFS expects that adult UWR Chinook salmon would continue to be stressed and injured, and may be susceptible to poaching, as they are released into habitat above Detroit. Prespawning mortality would likely continue to be high, because adult fish would continue to be concentrated in the reach below Minto Trap until ODFW opens the trap, and because stressful conditions during handling, transport, and release would likely inhibit some fish from spawning.

5.6.1.2 Juvenile Production

Minto Reach (N. Santiam River below Big Cliff Dam)
There are about 4.5 miles of river between the Minto trap (a dam and fish barrier) and the base of Big Cliff Dam. UWR steelhead have been passed above Minto dam into this reach since construction, and more recently UWR Chinook, progeny of fish releases above either Minto Dam or Detroit dam, have been noted there (Beidler and Knapp 2005). Since this area is below the major reservoirs, juveniles face no unusual challenges emigrating further downstream.

Beidler and Knapp (2005) reported on juvenile Chinook production surveys in lower North Santiam below Big Cliff Dam. Juvenile Chinook salmon in this reach could represent offspring of adults released above Minto Dam as well as those transported above Detroit reservoir for spawning in the upper North Santiam River subbasin. Juvenile Chinook densities varied among years, from 14 to 143 fish per mile, in surveys from 1993 through 2004.

Upstream of Detroit Dam (N. Santiam River)
The expansive habitat upstream of Detroit remains in relatively good shape; fish are able to spawn and reproduce. Prior to the building of Detroit Dam, Mattson reported that 71% of UWR Chinook spawned above the current location of Detroit Dam (USACE 2000, p. 5-35), indicating preferred habitat that likely remains. In the North Santiam River above Detroit Dam, Beidler and Knapp (2005) note that “many redds,” from transported hatchery-origin UWR Chinook, were observed, indicating strong, but unquantified production potential for these fish in this reach. No UWR steelhead have been released into and above Detroit dam and reservoir since construction, and thus there is no recent information on UWR steelhead productivity above Detroit Reservoir (the Proposed Action calls for all UWR steelhead to be released into the 4.5 mile reach above Minto Dam.)

Upstream of Detroit Dam (Breitenbush River)
Beidler and Knapp (2005) report that aquatic habitat on the Breitenbush River is “relatively pristine,” but they do not address fish production.

Little North Fork Santiam River (Downstream of Detroit)
ODFW releases some of the non-hatchery origin UWR Chinook salmon trapped at Minto into the Little North Santiam River. This practice would continue under the Proposed Action.

Beidler and Knapp (2005) report that juvenile production and adult spawning rates are relatively low from these efforts in the Little North Santiam River.

5.6.1.3 Dam & Reservoir Survival

Reservoir Survival

- Detroit Reservoir: For juvenile salmonids emigrating through, or rearing in Detroit Reservoir, there are numerous potential predators. However, little is known of the effects of Detroit Reservoir on UWR Chinook (or UWR steelhead, were they to be introduced there). Under the Proposed Action, Detroit Dam is rarely drafted to meet mainstem temperature targets, which tends to produce very slow water movement and possibly diminishes migration cues, potentially causing juvenile salmonids to residualize (i.e., behave like resident fish) rather than migrate downstream (Giorgi et al 1997). NMFS expects that under the proposed action, an unknown proportion of juvenile offspring of adults outplanted above Detroit Reservoir would not successfully emigrate from the reservoir as a result of predation and residualism.

- Big Cliff Reservoir: About two-thirds of the 2.6 mile reach between Detroit and Big Cliff dams consists of a narrow reservoir used for tempering power peaking flow changes resulting from discharges from Detroit Dam. The Proposed Action does not contemplate placing adults of any type in this reach, thus NMFS does not expect juvenile fish production here. However, progeny of fish released above Detroit Reservoir (UWR Chinook in the Proposed Action) are present because they must emigrate through, and may possibly rear in, this section. The effects of this reservoir upon fish survival are unknown. (Effects of peaking operations on fish in the reservoir and downstream are discussed in section 5.6.2).

- Minto Reservoir: The fish trap at Minto Dam, about 4.5 miles below Big Cliff Dam, utilizes an approximately 12-foot high dam (USACE 2007a) that acts as a fish barrier. This run-of-the river fixed-crest dam creates a very small reservoir that has mostly filled with sediment. The result is that there are virtually no "reservoir effects" upon UWR Chinook and UWR steelhead above Minto Dam, presenting instead more of the appearance of a river reach.

Dam Survival

Detroit/Big Cliff Complex: Neither upstream nor downstream fish passage was planned for when the Detroit/Big Cliff dam complex was constructed. There were no upstream passage provisions (though fish can be trapped at Minto, then trucked around the dams); and the downstream routes available to fish are only via incidental entrainment over the spillway, through the turbines, or via other outlets.

The Proposed Action would continue to kill and injure juvenile UWR Chinook salmon (and UWR steelhead, if adult fish are later released above Detroit Reservoir) as they migrate downstream through unscreened turbines and other outlets at both Detroit and Big Cliff Dams. Beginning in 2000, ODFW began releasing hatchery-origin adult UWR Chinook salmon above Detroit Reservoir, because spawning habitat was available; and large numbers of hatchery produced juveniles were also released into Detroit Reservoir in 2000 and 2001. Subsequent to this, ODFW placed traps below both Big Cliff and Detroit Dams and found that 51% of the smolts captured below Detroit survived dam passage, and below Big Cliff, 69% survived

(Beidler and Knapp 2005). These fish were comprised of UWR Chinook smolts, both hatchery releases and offspring of naturally-spawning adults, as well as possibly some kokanee. The researchers indicated that more research was needed to answer many questions, but their results give some indication of the effects upon fish passing through this two-dam complex.
Minto Dam:

Downstream passage

- Minto Dam is a 12-foot high concrete dam with a semi-ogee shaped fixed spillway crest which creates a velocity and physical barrier to upstream fish migration. Fish passage downstream over this dam (UWR steelhead juveniles and adult kelts, and UWR Chinook juveniles) could be through either of two routes: 1) over the spillway crest or 2) with the supply water to the fish trap ponds and ladder. The flow over the spillway crest varies from substantial depth during higher flow periods, to shallow depth during lower flow periods. Leaky flashboards at Minto Dam present points of potential entrainment and impingement. The effects of fish passing over this dam, particularly at shallow depths, have not been assessed but may be substantial, as fish may be injured by contact with rough surfaces and by landing on hard surfaces below the dam. The Proposed Action suggests, but does not clearly commit to, the possibility of replacing or upgrading this facility. Without certainty that this facility will be improved, NMFS expects the dam would continue to stay the same, likely causing fish injury and some level of mortality, as the baseline condition.
- In addition to downstream spillway passage at Minto Dam, there is a water intake for the adjacent fish facility which could entrain juvenile downstream migrants. Entrained juvenile fish would be transported to the adult fish facility via its water system. Residence time in the fish facility would delay downstream migration and increase risk of predation, depending upon the type and size of adult fish held in the facility.

Upstream effects

- Minto Dam exists to block fish and supply water to the fish facility; there is no volitional fish passage around Minto Dam, except accidentally during very high flows when a few adult fish may be able to swim over this barrier. UWR steelhead are first incidentally trapped here (there is no reason to trap them, except that Minto Dam is a fish barrier that precludes all passage) then later released upstream of this dam into the 4.5[1] miles of stream below Big Cliff Dam. UWR Chinook are also blocked and trapped here, then trucked to various dispositions; some non-hatchery origin UWR Chinook are released above Minto Dam. Thus, an effect of Minto Dam operation is to cause trapping and handling effects associated with trap operations. Trapping and handling causes stress and mechanical injuries, and delays fish migration. The Minto trap is typically operated three times a week, thus UWR steelhead could be held in the trap for several days, before being permitted to resume their upstream migrations. UWR Chinook, which are held until they are transported by truck to release locations or the hatchery, may be delayed or may be speeded up in the migration, depending upon the time of the year and where they are being trucked to. UWR Chinook and UWR steelhead are prevented from volitionally accessing the habitat between Minto and Big Cliff dams.

[1] USACE 2000 p. 5.35 and elsewhere incorrectly under-reports this distance in many instances.

- Minto Dam serves as a collection point for hatchery-origin UWR Chinook to be collected and “recycled”—trucked back downstream to increase angling opportunities for fisherman. Some hatchery-origin UWR Chinook are “recycled” multiple times, compounding handling effects. Another effect of Minto Dam is that it serves (along with the other dams) to concentrate fish below these dam, leading to increased susceptibility to fishing pressure. (USACE 2000, p 6-101)
- Minto Dam/Trap was designed collect broodstock for hatchery production (that is, not to gently handle fish that are to be released, and that need to survive long enough to spawn in the wild.) It was not designed for live sorting of adult fish (USACE 2007a, p. 3-52) as is the current practice, and outlined in the Proposed Action. Handling effects are thus larger than there would be associated with a modern facility with adequate space and modern facilities to optimally trap, sort and hold various types of fish (hatchery-origin, non-hatchery origin, steelhead, etc.)
- Early arriving UWR Chinook are not immediately allowed entrance into the trap and ponds, but must congregate below Minto Dam until admitted into the trap and separated. An effect of Minto Dam is to prevent timely access to spawning habitat (this applies to UWR Chinook and steelhead that that are eventually permitted access above Minto Dam.
- Upstream movement of juvenile UWR Chinook and UWR steelhead is generally prevented by Minto Dam.
- Despite these effects, there are also management and scientific benefits to the Minto Dam and trap including providing a convenient place to examine fish, leading to better understanding of their status and condition, and improved management practices. Captured fish might also be medicated, increasing the likelihood of survival until spawning, or they may be marked or tagged in various ways to increase management understanding of their migrations and habitat utilization.

5.6.1.4 Summary

Under the Proposed Action, upstream and downstream passage of UWR Chinook salmon and UWR steelhead would continue to be inadequate, causing fish injuries, mortalities, pre-spawning mortalities, residualism of juvenile fish, and stress. Although these adverse effects are not clearly quantified, NMFS expects that losses would continue to be moderate for upstream passage and high for downstream passage through the reservoirs and dams. The Proposed Action would continue to prevent safe access to historical habitat above Big Cliff and Detroit dams.

5.6.2 Water Quality/Hydrograph

Under the environmental baseline, those aspects of flow and hydrology under Action Agency control do not provide properly functioning habitat for UWR Chinook salmon and UWR steelhead (section 4.6.3.2). Increasing population and water demands in the Salem, Oregon, area indicate that flow-related anadromous fish habitat will likely continue to decline in the environmental baseline for the duration of this Opinion.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum and maximum flows, seasonal drafting and refilling, and ramping rates for changing discharge. Thus the hydrologic effects of the Proposed Action are the same as those described under the environmental baseline for the North Santiam River (Section 4.6.3.2).

5.6.2.1 Seasonal Flows

Although the USACE has committed to operating the Willamette Project in an attempt to meet seasonal flow objectives, operations modeling conducted by the USACE shows that it would not always be possible to meet the flow objectives while meeting other project priorities (Table 5.6-1).

Table 5.6-1 Estimated frequency that proposed minimum and maximum tributary flows would not be met downstream from Big Cliff Dam on the North Santiam River. Source: Donner 2008.

Dam	Period	Primary Use	Minimum Flow (cfs) [1]	Chance of Not Meeting Flow	Maximum Flow (cfs) [2]	Chance of Not Meeting Flow	
Big Cliff	Sep 1 – Oct 15	Chinook spawning	1,500	5%	3,000 through Sep 30, when possible	5%	Sep
	Oct 16 – Jan 31	Chinook incubation	1,200 [3]	2%			
	Feb 1 – Mar 15	Rearing Chinook and steelhead/adult Chinook migration	1,000	<1%			
	Mar 16 - May 31	Steelhead spawning	1,500	<1%	3,000	25%	Mar 16 - May 31
	Jun 1 – Jul 15	Steelhead incubation	1,200 [3]	<1%			
	Jul 16 – Aug 31	Chinook and steelhead rearing	1,000	<1%			

Exceedence of maximum flow objective over a 66-year record from 1936-2001 (probability figures are approximate).

1 Minimum flow will equal inflow or Congressionally authorized minimum flows, whichever is higher, when the reservoir is at a minimum conservation pool elevation. This avoids drafting the reservoir below minimum conservation pool and, where applicable, into the power pool.

2 Maximum flows are intended to minimize the potential for spawning to occur at stream elevations that might subsequently be dewatered at the specified minimum flow during incubation. It may not be possible to stay below these maxima, especially in the fall when drafting reservoirs in preparation for the flood damage reduction management period. Project operations will be managed to minimize the frequency and duration of necessary periods of exceedence.

3 When feasible, incubation flows should be no less than ½ the maximum 72-hour average discharge observed during the preceding spawning season. Efforts will be made to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period.

These proposed flow objectives are consistent with recommendations developed by NMFS' staff and ODFW managers familiar with fish habitat conditions in the North Santiam basin. In general, the lower the frequency that these objectives are not met, the better the conditions for salmon and steelhead survival. Because these flows closely correlate with fish management agency recommendations and the best currently available information, these proposed operations are highly protective and an improvement over conditions that prevailed prior to 2000. The high projected frequency that the flow objectives would be achieved suggests that under the PA flow-related habitat needs in the lower North Santiam River would generally be met. However, continued water withdrawals for out of stream use (e.g. irrigation) may reduce flows and reduce flow-related habitat. This issue is discussed in Section 5.6.2.4 below.

Detroit and Big Cliff operations would continue to reduce the flows in the lower North Santiam River during late winter and spring (compared to historical levels) while the reservoirs are being refilled. During this period, juveniles of both species are rearing, smoltifying, and migrating through the Willamette River system to the Pacific Ocean. Spring Chinook fry are emerging from the gravels and winter steelhead are spawning in the North Santiam River downstream from Big Cliff Dam. This flow reduction effect of the proposed action may have its largest biological effect on emigrating juvenile spring Chinook and winter steelhead. Reductions in spring flows may also interfere with recruitment of age-0 rainbow trout (*O. mykiss*) (Mitro et al. 2003). Winter flow reductions associated with active flood control operations may dewater Chinook salmon redds, reducing egg survival. These effects are expected to continue over the life of the Proposed Action.

By placing high priority on maintaining full-pool conditions at Detroit reservoir through the Labor Day weekend, sufficient water would be available in most years to meet the Chinook spawning and incubation objective downstream from Big Cliff Dam (Table 5.6-1) (see additional effects on the S. Santiam in section 5.5). However, maintaining pool levels at Detroit during summer is likely to conflict at times with achievement of target flows for rearing of juvenile salmonids in the lower North Santiam River, particularly if consumptive use of water from the lower river increases. The magnitude of this adverse effect cannot be quantified, and improved stream gauging in lower reaches of the North Santiam would identify whether flows released at Big Cliff are sufficient to protect fish habitat in both the upper and lower reaches. Additionally, studies of fish-flow relationships in multiple reaches of the North Santiam below Big Cliff are needed to better define fish habitat needs in each reach. Finally, the results of these studies should be used to adjust flow releases and reservoir management at Detroit and Big Cliff for fish habitat needs, so that the Action Agencies can assure that the needs of ESA-listed salmonids are sufficiently protected.

5.6.2.2 Frequency of Channel-forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows downstream from Big Cliff Dam, project operation would continue to limit channel complexity and thereby limit rearing habitat for juvenile Chinook salmon and steelhead. Peak flow reduction may also reduce the recruitment and suitability of channel substrates for spawning salmon and steelhead. These effects are expected to continue and may worsen over the life of the Proposed Action.

Reducing peak flows during flood events could benefit spring Chinook salmon by reducing the likelihood that high flows would scour redds and disrupt incubating eggs (compared to the unregulated condition).

5.6.2.3 Flow Fluctuations

Under the Proposed Action, the USACE would continue to operate Big Cliff Dam as a reregulating facility, to dampen discharge fluctuations caused by load-following operations at the Detroit project. This action would protect juvenile salmonids in the North Santiam River downstream from Big Cliff Dam from stranding during load-following operations. However, juvenile salmonids in the river reach downstream from Big Cliff Dam would continue to be subjected to rapid discharge reductions during active flood control operations and emergency events and could become entrapped and stranded. This effect would be most pronounced immediately downstream from Big Cliff Dam and would decrease in a downstream direction, as flow from unregulated tributaries enters the river. Additionally, juvenile Chinook salmon and steelhead could be stranded in Big Cliff Reservoir during daily load-following operations, although no data are available to assess the potential magnitude of this loss.

In summary, the Proposed Action would continue to entrap and strand an unquantified number of juvenile UWR Chinook salmon and UWR steelhead in the North Santiam River downstream from Big Cliff Dam during flood control operations as well as in Big Cliff Reservoir during daily load-following operations. The number of individual fish that would be killed as a result of flow fluctuations is unknown, but NMFS expects that this repeated activity would be significant and contribute to decreased abundance and productivity of UWR Chinook salmon and UWR steelhead.

5.6.2.4 Water Contracting

Reclamation has contracted a total of 9,474 acre-feet of water stored in Detroit and Big Cliff reservoirs to irrigators along the North Santiam River (USACE 2007a), which constitutes a small fraction of the surface water withdrawals issued by OWRD. Another 1,647 acre-feet are contracted to users downstream from the confluence of the North and South Santiam rivers served by USACE reservoirs in both drainages. As part of the proposed action, Reclamation intends to issue contracts to an additional 2,796 acre-feet to users within the North Santiam basin and an additional 350 acre-feet in the lower Santiam basin. These new contracts would be wholly or partly served by water stored in USACE's North Santiam River basin projects (primarily Detroit and Green Peter). Included in the Proposed Action is the option to lease up to 95,000 acre-feet throughout the Willamette basin, an increase of 14,569 acre-feet above existing and pending contracts.[2]

USACE and Reclamation intend to continue serving these contracts with water released from storage to maintain project and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Santiam River during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water service could reduce flows in

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[2] No specific location for these future contracts has been specified. If these contracts follow the areal distribution of current Reclamation contracts, about 21 percent or 3,059 acre-feet would be issued to serve areas in the North Santiam subbasin.

some sections of the North Santiam River by 119 cfs, and in the Santiam River mainstem by about 135 cfs, an increase of 41 cfs over existing Reclamation service. Given the existing low flow conditions common during late summer in the North Santiam River reach downstream from Stayton, Oregon, this level of Reclamation-supported water development could further exacerbate poor habitat and water quality conditions in the lower North Santiam and the mainstem Santiam rivers. Low flows and high rates of water diversion in the North Santiam River have substantially reduced habitat area and production potential for rearing juvenile anadromous fish (E&S 2002). These effects are expected to continue and worsen over the term of the Proposed Action.

5.6.2.5 Flow-related Research, Monitoring & Evaluation (RM&E)

The Action Agencies would develop and implement a comprehensive research, monitoring and evaluation program to determine compliance with, and effectiveness of, their flow management action. The RM&E program would be designed to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams, and related effects on ESA-listed fish species. The recommendations for a Flow Management RM&E program would be integrated into the comprehensive program overseen by the RM&E Committee and following the principles and strategic questions developed by the committee.

5.6.3 Water Quality

Under the environmental baseline, water quality (temperature and TDG) do not provide properly functioning habitat for UWR Chinook and UWR steelhead. Under the proposed action these conditions would not improve, and could further degrade.

The Action Agencies propose to continue operating the dams under current configurations and flow regimes. No water temperature control measures are proposed in the North Santiam watershed. Potential operational changes that could be carried out under the current configuration of the dams to address temperature problems are not part of the Proposed Action but may be considered as part of the Willamette System Review Study for future implementation.

5.6.3.1 Water Temperatures

Water temperature conditions downstream from Big Cliff Dam currently limit the abundance, productivity, and life history diversity (i.e., spawning, incubation, and emergence timing) of UWR Chinook salmon and UWR steelhead in the North Santiam below Big Cliff Dam and in the mainstem Santiam River (see Section 4.6.3.3.1).

Beginning in the late 1960s, state and federal fisheries managers began to express concerns that changes in the thermal regimes downstream from the large Willamette Project dams in the McKenzie and Santiam watersheds were adversely affecting salmon and steelhead. Following Congressional authorization in 1981, the USACE (1982) produced the first in a series of reports responding to these concerns and in 1984; the USACE initiated the Willamette System

Temperature Control Study. That study produced two primary products: a Santiam sub-basin report (USACE 1988); and, a McKenzie sub-basin report (USACE 1987). The Santiam sub-basin report determined that modifying the intake tower at Detroit Dam and constructing a multilevel release system that drew water from different elevations in the reservoir could restore the natural seasonal water temperature hydrograph to the North Santiam River downstream from Big Cliff Dam.

As discussed in Section 4.6.3.3.1), an ad hoc experiment conducted in 2007 during an emergency powerhouse outage at Detroit and Big Cliff dams showed that it is possible to operate existing systems at Detroit and Big Cliff dams in a manner that substantially lessens the effects of these projects on water temperatures downstream from Big Cliff Dam (see Figure 5.6-1). These operations did cause TDG to exceed Oregon water quality criteria for a short distance downstream from the dam.

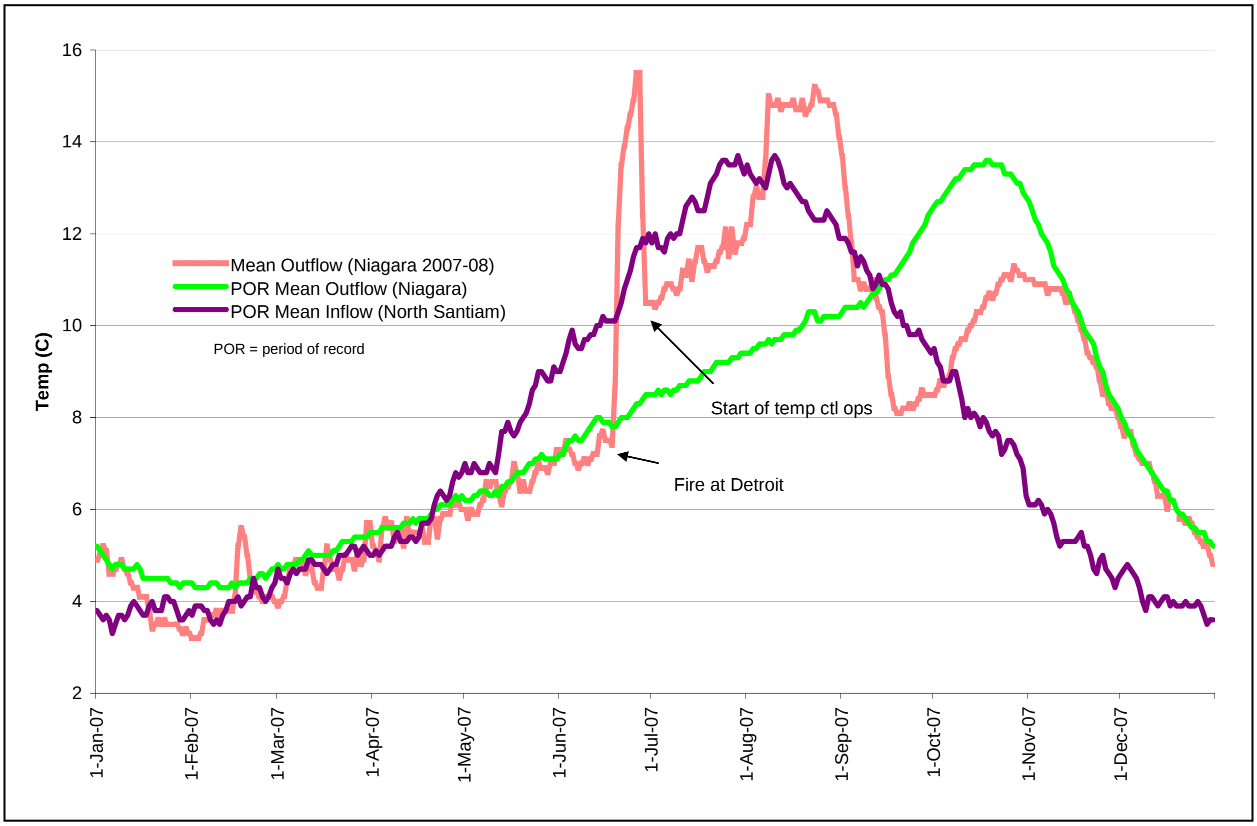

Figure 5.6-1 Temperature regime downstream of Detroit Dam (Niagara gage) and upstream of Detroit reservoir (North Santiam gage) in 2007. Operations resulted in an improvement in water temperatures below Detroit Dam (i.e. more similar to natural temperatures above Detroit reservoir).

The Action Agencies have not proposed to modify the intake towers at Detroit Dam for temperature control. However, they propose to further evaluate temperature control at dams without such facilities, including Detroit Dam, under the proposed Willamette System Review Study. The goal of that study, which would be completed in three phases, "would be to recommend for implementation those measures shown to be technically feasible, biologically justified, and cost-effective" (USACE 2007a). The Action Agencies indicate that, assuming such a project proves feasible and is funded, a facility to provide temperature control could be installed by 2017.

Although the 2007 emergency operations demonstrated that Detroit Dam, in its existing configuration, could be operated to reduce its adverse water temperature effects, the Action Agencies have not proposed further evaluation or implementation of this alternative.

Under the proposed action, correction of adverse water temperature conditions in the North Santiam would not be guaranteed and such conditions would continue to adversely affect abundance and productivity of UWR Chinook and UWR steelhead until and unless water temperature control was selected as a high priority project under the Willamette System Review Study, final design completed, and the measure implemented. The expected future conditions of water temperatures below Big Cliff are therefore expected to continue to adversely affect the survival of adult, eggs, and alevins as has been occurring in recent years (Figure 5.6-2; Figure 5.6-3).

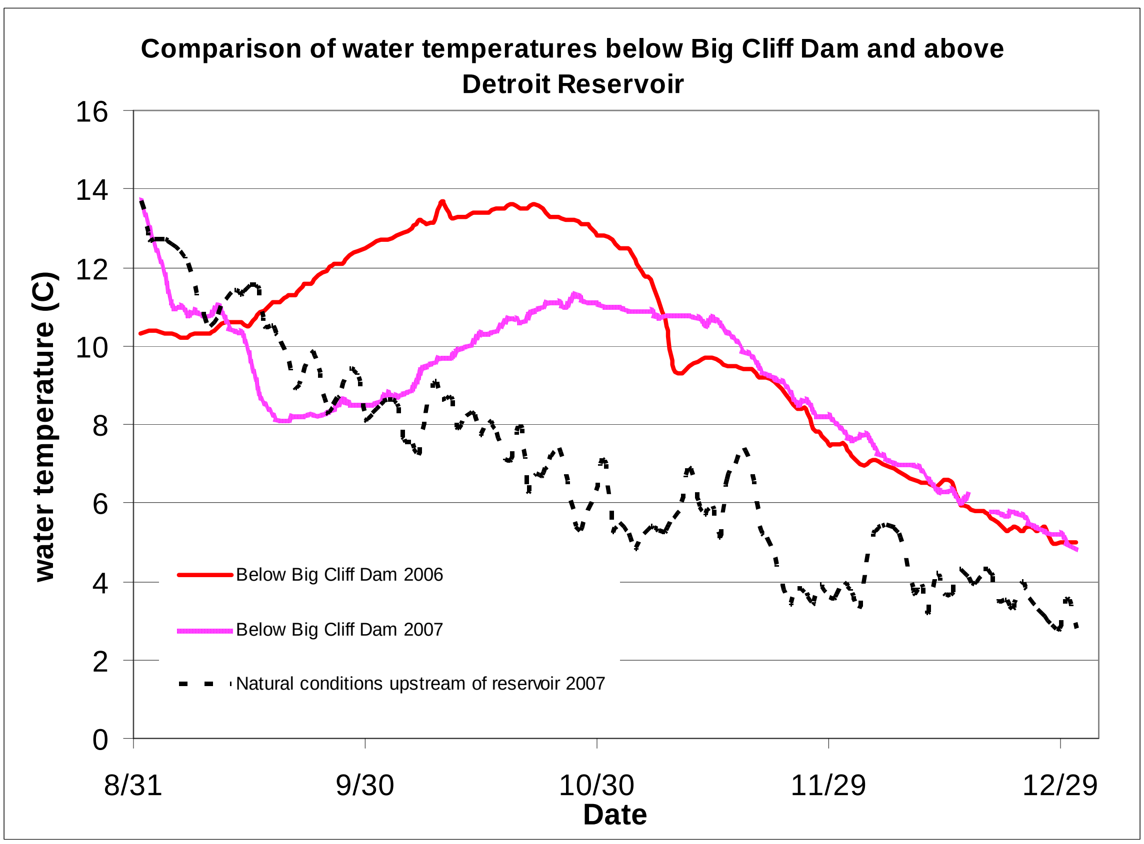

Figure 5.6-2 Comparison of observed water temperatures below Big Cliff/Detroit dams (USGS gage 14181500) and observed natural water temperatures (daily average) upstream of Detroit reservoir in the North Santiam River (USGS gage 14178000) during the spring Chinook spawning and egg incubation period.

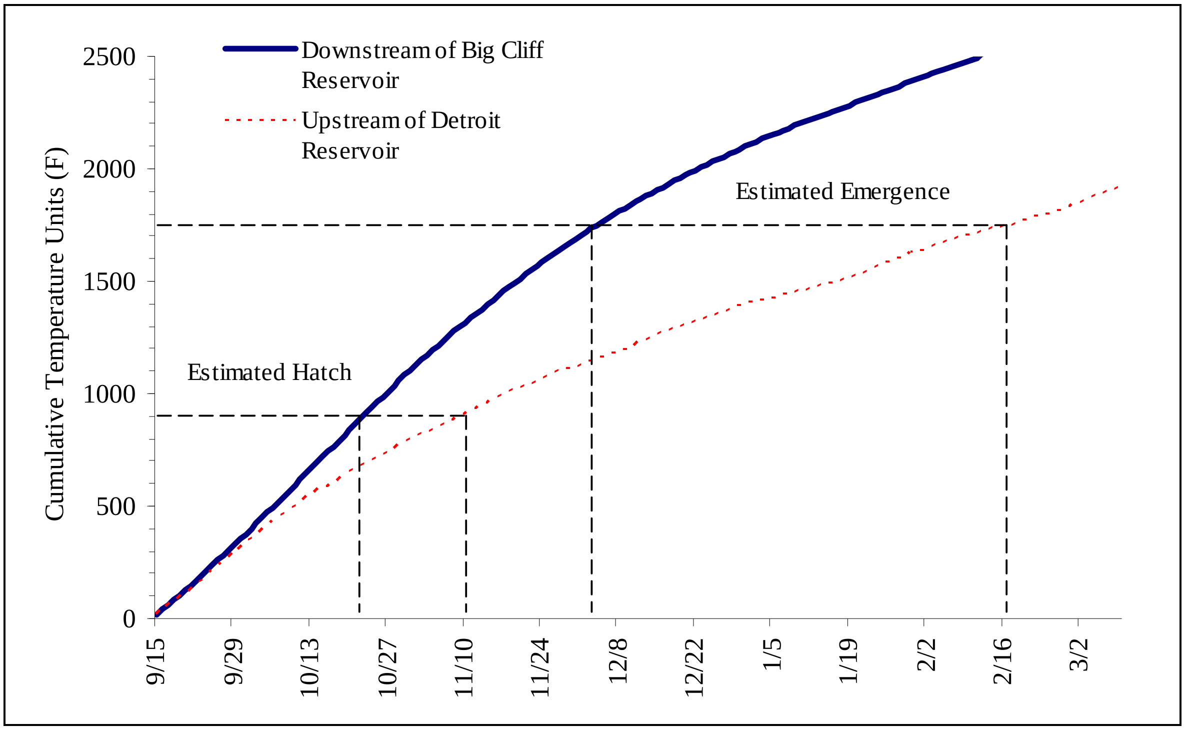

Figure 5.6-3 Estimated hatch and emergence timing of juvenile Chinook above and below Detroit/Big Cliff dams and reservoirs in 2004-2005. Source: Taylor and Garletts (2007)

5.6.3.2 Total Dissolved Gas

The Proposed Action would maintain the current dam configurations in which spill operations create TDG concentrations high enough to kill UWR Chinook salmon and UWR steelhead yolk sac larvae one mile (Willis 2008) downstream from Big Cliff Dam, potentially limiting the abundance, productivity, and juvenile outmigrant production of these North Santiam subbasin populations. The proposed operations would continue to minimize the frequency of spill operations but cannot entirely prevent them. Spill occurs primarily during high flow events during winter months, affecting UWR Chinook salmon in redds, but spill also occurs infrequently in other months when emergency events cause powerhouse shutdowns. As noted above in section 5.6.3.1, when an emergency powerhouse shutdown occurred in 2007, TDG concentrations spiked to high levels. The Proposed Action does not include any measures to develop emergency bypass valves or protocols using existing facilities to moderate this sudden increase in TDG or to quickly address potential effects on UWR Chinook salmon and UWR steelhead downstream from Big Cliff Dam.

Willis notes (Willis 2008) notes that spill over approximately 1,400 cfs generates more than 115% total dissolved gas down to approximately 1 mile below Big Cliff Dam and is projected to occur at the following frequency:

- for UWR Chinook juveniles, Oct 19%, Nov 42%, Dec 32%, Jan 39%; (Willis 2008)
- for UWR steelhead,
  - Adults: Apr 3%, May 0% (Willis 2008)
  - Juveniles: Apr 3%, May 0%, Jun 3%, Jul 0%, Aug 0% (Willis 2008)

5.6.3.3 Summary

Under the environmental baseline, operations at Detroit and Big Cliff dams have adversely affected water temperatures and TDG in the lower North Santiam River. These effects would continue under the Proposed Action, limiting abundance and productivity of UWR Chinook salmon and UWR steelhead.

5.6.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the North Santiam River subbasin that will affect UWR Chinook salmon and UWR steelhead are listed below. As noted above, the mainstem Santiam River is considered part of the North Santiam River subbasin for the purpose of this analysis.

- Continue to operate Big Cliff and Detroit dams, blocking sediment and large wood transport from upstream reaches and tributaries into the North Santiam River below Big Cliff Dam.
- Continue to reduce peak flows as part of flood control operations at the two Project dams, preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids
- Continue the existence and maintenance of 3.87 miles of revetments along the mainstem Santiam River, preventing channel migration and reducing channel complexity.
- Study the potential for gravel augmentation and large wood restoration projects in the North Santiam subbasin to improve salmonid habitat.
- Study effects of Project dams and revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.6.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.6.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5-6-4 (end of this Section, 5.6) and described below.

Under the Proposed Action, operation of Big Cliff and Detroit dams for flood control would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and alcoves. As a result, already impaired habitat would continue to degrade, limiting the abundance, productivity, and juvenile outmigrant production of the North Santiam subbasin populations of UWR Chinook salmon and UWR steelhead. The Action Agencies propose to study the potential for gravel augmentation and large wood restoration projects in the North Santiam River to improve salmonid habitat (USACE 2007a), but do not identify the duration of this study nor commit to follow through with recommendations of the study. Other sections of the Proposed Action describe studies of revetments and floodplain restoration, but the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the North Santiam subbasin.

As described above in sections 4.6.3.4, operation of Detroit and Big Cliff dams has trapped gravel and large wood from 60% of the subbasin and has reduced the magnitude of peak flows. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, and side channels, which are necessary components of rearing and spawning habitat for both UWR Chinook salmon and UWR steelhead. The only large tributary that enters the North Santiam downstream of Big Cliff Dam is the Little North Santiam, which cannot contribute sufficient sediment and large wood to compensate for the loss in upstream supply.

Continued existence and maintenance of the USACE revetments would prevent river migration and contribution of sediment from 3.87 miles of streambank in the mainstem Santiam River, further depriving the lower river of sediment and the ability to create new gravel bars or side channels. Reduction in peak flows would exacerbate these problems by reducing the frequency of flows with sufficient magnitude to re-shape the channel and form new habitat.

In summary, the continued degradation of habitat in the North Santiam subbasin downstream of Big Cliff and Detroit dams would likely reduce the carrying capacity of this habitat for rearing juvenile fish and spawning adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. It is likely that areas of spawning gravel in the lower river would continue to be replaced with coarse bed material unsuitable for spawning, and that rearing habitat in the form of alcoves and side channels would continue to be reduced as well. Because these populations do not have safe passage and access to historical habitat upstream of the two dams, a reduction in spawning habitat in the reach below Big Cliff could further limit spawning and contribute to overuse of redds (i.e., a second female could disrupt the eggs of one that's already spawned). Additionally, a lack of complex rearing and refugia habitat in the mainstem Santiam and lower North Santiam Rivers could limit juvenile outmigrant production in the subbasin. Aside from unspecified habitat restoration actions that may result from proposed habitat, revetment, and gravel studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the North Santiam subbasin. These effects would extend 46.4 miles to the confluence of the S. Santiam River affecting both juvenile and adult UWR Chinook and UWR steelhead (Willis 2008).

5.6.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (section 4.6.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.6-4 and described below.

Under the Proposed Action, operation of Big Cliff and Detroit dams and continued existence and maintenance of 3.87 miles of revetments in the mainstem Santiam River would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential habitat restoration and gravel augmentation in reaches below the dams, there is no certainty that any restoration work would be done during the term of this Opinion. Given the adverse water temperature conditions in the North Santiam River below Big Cliff Dam associated with Project operations (as described in Section 5.6.3 Water Quality), and the lack of fish passage to historical upstream habitat (as described in Section 5.6.1 Habitat Access/Fish Passage), further degradation of riparian vegetation and floodplain connectivity would result in a net reduction in the already limited habitat available to UWR Chinook salmon and UWR steelhead in the North Santiam subbasin.

The extent and composition of riparian vegetation in the North Santiam subbasin would continue to be impaired by Big Cliff and Detroit dam operations under the Proposed Action by interfering with the processes needed for new floodplain forests to establish. As described above in section 5.6.4.1, Detroit and Big Cliff dams would continue to trap sediment and large wood and reduce the magnitude of peak flows in the North Santiam and Santiam subbasins. Additionally, the continued existence and maintenance of 3.87 miles of revetments in the mainstem Santiam River would further prevent river migration and contribution of sediment and large wood from streambanks of the Santiam River. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. The reduced width and continuity of riparian forests could prevent the shading of the North Santiam and Santiam rivers, rendering the rivers susceptible to increased water temperatures.

Flood control operations in the North Santiam subbasin have probably increased development within the floodplain and indirectly facilitated clearing of riparian vegetation for agricultural, residential, and urban development, and this effect would continue under the Proposed Action. However, additional development in the floodplain is at the discretion of private parties, so these effects are discussed in Chapter 6 (Cumulative Effects).

In summary, the proposed operation of Big Cliff and Detroit dams and continued existence and maintenance of revetments along the mainstem Santiam River will continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the North Santiam subbasin downstream of Big Cliff and Detroit dams. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. Aside from unspecified habitat restoration actions that may result from the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the North Santiam subbasin. Given the uncertainty in upstream and downstream passage to historical habitat above Big Cliff and Detroit dams (see Section 5.6.1), continued degradation of limited spawning and rearing habitat under the Proposed Action will reduce the abundance and productivity of North Santiam subbasin populations of UWR Chinook salmon and UWR steelhead.

5.6.5 Hatcheries

As described in Chapter 2, the Proposed Action is to continue to artificially propagate hatchery spring Chinook salmon (ODFW stock 021) and summer steelhead (ODFW stock 024) and release these fish into the North Santiam River at Minto Dam. Further details about these programs are described in the North Santiam spring Chinook HGMP (ODFW 2008a) and Upper Willamette summer steelhead HGMP (ODFW 2004a).

Below is an analysis of the specific effects of these actions on listed spring Chinook and winter steelhead in the North Santiam River.

5.6.5.1 Hatchery Operations

There are two hatchery-related facilities in the North Santiam watershed—1) Marion Forks Hatchery, located upstream of Big Cliff and Detroit Dams, and 2) Minto Dam facility, located about seven km below Big Cliff Dam. Spring Chinook broodstock are collected at Minto Dam and held there until spawning. The eggs are transferred to Marion Forks Hatchery upstream and reared until the fish reach smolt size. Smolts are then transferred back to a pond at Minto Dam and released. Summer steelhead are also released at Minto Dam. Broodstock for the summer steelhead program are collected at Foster Dam on the South Santiam.

As described in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section 5.1 above, there are two primary concerns with the effects of hatchery facilities on listed spring Chinook and winter steelhead in the South Santiam River- 1) risk of facility failure leading to fish mortality in the hatchery (particularly progeny of wild fish), and 2) improperly screened water intakes at the hatchery facility that lead to the mortality or injury of naturally rearing listed fish. Other potential adverse of effects of the facilities or related activities are addressed below under their appropriate section (i.e. effects of disease-laden water discharges from a hatchery on listed fish downstream).

The occurrence of catastrophic loss (or unforeseen mortality events) of spring Chinook at Marion Forks Hatchery has been very low over the last several decades and of no consequence to the conservation and recovery of spring Chinook or winter steelhead. All of the normal safeguard equipment and procedures are being implemented at this hatchery. Since there have been few significant mortality accidents at this hatchery in the past, and the numbers of wild fish incorporated into the hatchery broodstocks are low, the risk of facility failure is deemed to be a low risk to wild spring Chinook and winter steelhead in the North Santiam populations at this time**.**

The water intakes for the Marion Forks Hatchery water supply are located on Horn Creek and Marion Creek. Water is gravity fed from the streams to the hatchery. These water intakes do not meet NMFS' criteria for listed juvenile salmon and steelhead. However, no listed fish are present in Horn or Marion Creeks. No critical habitat has been designated in this area.

5.6.5.2 Broodstock Collection

In the North Santiam River, the only broodstock collection is for spring Chinook at Minto Dam (approximately five km downstream from Big Cliff Dam). Hatchery summer steelhead are also collected at Minto Dam and recycled downstream and/or removed from the river. There is no effect of these collections on listed winter steelhead because trapping for Chinook and summer steelhead occurs after the run of winter steelhead is over (July through October). Winter steelhead have already spawned by this time.

There is an impact of this trapping on wild spring Chinook salmon. A proportion of the wild Chinook captured at Minto Dam are purposefully incorporated into the hatchery broodstock in order to maintain an "integrated" hatchery stock. The other wild fish not used for broodstock are outplanted into other spawning areas, like the Little North Santiam River, or released downstream of Minto Dam to spawn naturally (Schroeder et al. 2006). No wild Chinook are outplanted above Big Cliff and Detroit Dams.

Further details on the broodstock collection schedules are described in the Supplemental BA and North Santiam spring Chinook HGMP (ODFW 2008a).

At the Minto trapping facility, on an annual basis approximately 1000 UWR Chinook are observed (that is, their migration is blocked and they congregate below Minto dam); of these, 700 fish are handled. 6% of handled fish die or are injured from the procedures, primarily from May through October. In addition, of those UWR Chinook transported (that is, trucked), ~700 fish, approximately 1% die. (Willis 2008)

Approximately 1000 UWR steelhead are observed, and approximately 400 of these are handled (released immediately above Minto Dam, primarily). Of these ~400 that are handled, approximately 8 are injured and 4 are die.

5.6.5.3 Genetic Introgression

Spring Chinook

Significant genetic introgression from hatchery fish into the natural population in the North Santiam has occurred since Big Cliff and Detroit Dams were constructed and this mitigation hatchery program was initiated. Ever since all returning hatchery fish have been mass marked (adipose finclipped) so that they could be distinguished from naturally-produced fish in 2001, most of the return has been fish of hatchery-origin (see Figure 4.6.3 and Table 4.6.1 in the Environmental Baseline chapter). In addition, the majority of the fish spawning naturally below Minto Dam have been hatchery fish. The percentage of natural-origin fish recovered in carcass surveys on the spawning grounds has ranged from 3% to 33% from 2002-2006 (Table 5.6-2). Hatchery origin fish have dominated the spawning grounds and the percentage of natural-origin fish incorporated into the hatchery broodstock was low until 2006. Thus the PNI values for this population have been low since 2002—indicating hatchery fish are dominating genetic processes in this population (see Figure 5.2-3).

Table 5.6-2 Composition of spring Chinook salmon in the North Santiam subbasin[a] based on carcasses recovered. Weighted for distribution of redds among survey areas. Copied from McLaughlin et al. (2008).

	Fin-	Unclipped[b]		Percent
Run year	**clipped**	**Hatchery**	**Wild**	**Wild[c]**
2001	385	43 (43)	56	12 (6)
2002	230	44 (49)	45	14 (13)
2003	855	89 (77)	27	3 (4)
2004	321	21 (27)	56	14 (15)
2005	163	25 (24)	80	30 (30)
2006	109	12 (17)	59	33 (32)

[a]Mainstem North Santiam River from Minto to Bennett Dam, plus the Little North Santiam River.
[b] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).
[c] Percentage not weighted for redd distribution is in parentheses.

Table 5.6-3 Composition of spring Chinook salmon without fin clips that were spawned as broodstock for the hatchery program in the North Santiam subbasin after collection at Minto Trap, based on the presence or absence of thermal marks in otoliths, 2002–2006. Run of wild fish is estimated from Bennett dam counts. Source: McLaughlin et al. (2008)

	Unclipped[a]		Fin-clipped	Percent wild—	
River, year	**Wild**	**Hatchery**	**hatchery**	**in broodstock**	**of run**
2002	4	7	671	0.6	0.7
2003	2	17	599	0.3	0.7
2004	12	13	541	2.1	2.4
2005[b]	18	16	470	3.6	2.7
2006	197	12	335	36.2	***c***

[a] Includes fish with partial or questionable fin-clips.
[b] Otoliths were analyzed for 21 fish (11 wild).
[c] Bennett Dam trap on the North Santiam was not operated in 2006.

In recent years, it is likely some proportion of the natural-origin fish returns are progeny of hatchery fish. Hatchery fish comprise the majority of spawning in all areas (above and below Big Cliff/Detroit dams). However, it is unknown what area (or combination of areas) are producing the wild Chinook. In the area downstream of Big Cliff/Detroit Dams, the release of warm water in the fall as the reservoirs are being drawn down for flood control causes high mortality of spring Chinook eggs incubating in the gravel. Natural production is likely to be low in this area because most of the spawning occurs in the vicinity of Minto Dam—the area most impacted by warm water releases because its only five km downstream of Big Cliff Dam. The outplanting program of releasing adult Chinook above Detroit Dam did not begin until 2000. However, releases were dramatically increased beginning in 2002; with over 1,600 fish released that year (Beidler and Knapp 2005). The recent increase in 2006 and 2007 in the percentage of wild fish returns (and greater number of wild fish even though overall returns were lower to the Willamette) may be natural production from the outplanting program. All of these uncertainties stress the need for more monitoring and evaluation to discern where natural production is currently coming from in this population.

Given these uncertainties, hatchery management should continue to outplant adults above Detroit Dam and continue to incorporate wild fish into the broodstock, according to the sliding scale matrix described in the HGMP. As more information becomes available, it may be warranted to start managing hatchery fish on the spawning grounds below Minto Dam, particularly if returns of wild fish continue to be at least several hundred fish. The long-term vision for this mitigation program, as described in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section, is to gradually reduce the influence of hatchery fish in the wild as natural production increases. In the long-term it will likely be necessary to manage for low levels of hatchery fish spawning below Minto Dam, particularly when the key limiting factors with the dams are corrected, and natural production increases in the substantial amount of habitat that is still available below Big Cliff/Detroit Dams.

Winter Steelhead

There are no hatchery winter steelhead released in the North Santiam River. However, hatchery summer steelhead do spawn naturally in the same areas as winter steelhead (Schroeder et al. 2006). Since there is some overlap in the spawn timing of summer- and winter-run fish from February through March, the potential exists for summer steelhead to interbreed with winter steelhead in the North Santiam River. However, the likelihood of this occurrence is low. Most of the summer steelhead spawning occurs in January and February (Schroeder et al. 2006). The peak of the listed winter steelhead run over Willamette Falls (downstream of the South Santiam) occurs from late February through March (Myers et al. 2006).Actual spawn timing of these winter steelhead in the North Santiam has been as late as May 22nd (Taylor 2007)

The primary concerns with the hatchery summer steelhead program are predation and competition, which are addressed below.

5.6.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the North Santiam subbasin, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from Minto Dam in the North Santiam River. Significant juvenile fish rearing occurs in the lower river and in the mainstem Santiam River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the Mainstem Willamette River Effects Section 5.10.

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the North Santiam River. The risk of hatchery fish spreading diseases in the North Santiam may be substantial since Chinook congregate at the base of Minto Dam throughout the summer until spawning time in September and October. There is no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.6.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

As described in the "genetic introgression" above, hatchery summer steelhead spawn naturally in winter steelhead habitat. Summer steelhead spawning has been widespread; with the number of spawners positively correlated with run strength (Schroeder et al. 2006). It is likely that progeny from these summer steelhead would negatively affect listed juvenile winter steelhead rearing in their natal habitat. It is unknown whether there is in fact a competitive interaction due to limited resources. However, any interaction between non-native summer steelhead and listed winter steelhead would be undesirable. Juvenile summer steelhead would have a competitive advantage because these fish would hatch earlier and be of larger size than winter steelhead. Monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

Adults
Given the problem of crowding of adult Chinook at the base of Minto Dam, there is the potential for competitive interactions for space. There is a limited amount of habitat in the holding pool at the base of the dam. It is unknown whether adult fish are displaced into suboptimal holding habitat downstream due to the high number of fish at the base of the dam. Given the primary

limiting factors for this population (habitat access, temperature problems), competition is not likely one of the primary or secondary limiting factors.

5.6.5.6 Predation

Hatchery fish released into the population areas throughout the Willamette Basin can predate upon co-occurring wild fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few individual fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g. one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead (that are the progeny of naturally spawning summer steelhead in winter steelhead habitat) could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

5.6.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that will help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These “non-migrants” will be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any finclipped, residual summer steelhead in all recreational fisheries. These regulation changes will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish on wild steelhead and spring Chinook.

5.6.5.8 Fisheries

As discussed in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural- or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.6.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed "masking" by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases, McLaughlin et al. 2008).The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.6.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see "General effects of hatchery programs on ESA-listed salmon and steelhead" section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted alive above the dams in an effort to restore natural production in historic habitats. This provides benefits to aquatic and terrestrial food chains.

5.6.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS' (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is summarized in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.6.6 Summary of Effects on the North Santiam Chinook Salmon & Steelhead Populations

Table 5.6-4 summarizes anticipated effects of the Proposed Action to VSP parameters for North Santiam populations of Chinook salmon and steelhead. These effects are described in more detail in this section.

5.6.6.1 Abundance

There have been substantial impacts of the Proposed Action on steelhead and Chinook in the North Santiam subbasins. The Proposed Action is essentially status quo management of the Projects and thus the abundance of these species are likely to remain at similar abundance levels and are not likely going to increase. NMFS is concerned particularly for Chinook since their abundance is low and their trend is clearly declining.

5.6.6.2 Productivity

Productivity of Chinook in the North Santiam has been declining over the long- and short- terms. The recent decline in abundance is of particular concern because productivity has not been increasing. The current hatchery programs represent risks to the listed populations. However, the recent returns of natural-origin fish are likely the offspring of hatchery spawners. Thus, production is so poor in this population that hatchery supplementation has to be relied upon until other limiting factors are corrected. Even though this is a high risk scenario, alternatives are limited due to the poor status of natural-origin fish. Without substantial improvements to the habitat conditions below Big Cliff/Detroit dams and adequate passage of fish above these dams into historical habitats, NMFS expects the productivity and capacity of this population to reproduce naturally will not improve but will remain at a very low level. The Proposed Action lacks certainty that any improvements would be carried out during the term of this Opinion.

5.6.6.3 Spatial Structure

The Proposed Action continues to limit Chinook and steelhead access to historic habitats above Big Cliff and Detroit dams. Access is dependent upon trap and haul at Minto Dam (a few miles downstream of Big Cliff Dam). Success of the outplanting program has been mixed for Chinook salmon; with high prespawning mortality rates in outplanted fish in most years. Restoring production above Big Cliff/Detroit Dams, with appropriate survival of adult and juveniles, is needed to increase the spatial distribution of the population and increase the capacity of the population to respond to fluctuating environmental conditions. However, the Proposed Action would not provide safe upstream and downstream passage.

5.6.6.4 Diversity

Many aspects of the North Santiam populations have been and will continue to be impacted by the Proposed Action. Since the impacts have been substantial, there has undoubtedly been changes in the diversity of the Chinook and steelhead in the North Santiam. Population traits are now not as diverse as the historic populations, and this decreases the ability of salmon to respond and survive in response to fluctuating environmental conditions. The habitat changes that have occurred by the Proposed Action downstream of the Projects have affected the population in an unquantifiable manner. The influence of hatchery fish on the wild population also represents risk to the diversity of the natural-origin population.

5.6.7 Effects of the Proposed Action on Designated Critical Habitat

The North Santiam River and many of its tributaries have been designated as critical habitat for UWR Chinook salmon and UWR steelhead. The PCEs identified in this portion of critical habitat include sites for spawning, rearing, and migration. Table 5.6-4 summarizes anticipated effects of the Proposed Action to these PCEs. The effects are attributable to a lack of functional fish passage at USACE dams, the effects these dams and their reservoirs have on water quality and physical habitat conditions in the lower reaches of the North Santiam River, and continued existence and maintenance by the USACE of 3.87 miles of revetments. The following PCEs will be adversely affected by the Proposed Action:

- Freshwater spawning sites above Detroit and Big Cliff dams, with flow regimes, water quality conditions, and substrates well suited to the successful spawning, incubation, and larval development of UWR Chinook and UWR steelhead, will remain marginally accessible to these fish. Spawning habitat will remain accessible to these fish below Big Cliff (and the Minto Trap), but much of this habitat is degraded as a result of ongoing Project operation. Flow releases from the dams during late summer and fall will continue to create adverse temperature conditions for UWR Chinook, contributing to elevated pre-spawning mortality and causing delayed spawning, embryo mortality, and accelerated incubation in the habitat below Big Cliff. This habitat is further degraded by the Project’s interruption of sediment transport, such that new gravels needed for spawning are not replacing those that move downstream during high flows. Additionally, continued existence and maintenance of revetments downstream of Big Cliff prevent channel formation processes that might otherwise allow for new gravels and spawning habitat to be created.

- The quantity and quality of freshwater rearing sites for juvenile UWR Chinook and UWR steelhead will remain limited and degraded in the fully accessible portion of the mainstem North Santiam River below Big Cliff, and may continue to decline. Diminished peak flows, lack of sediment and LWD delivery from areas above Project dams, and revetments contribute to losses of off-channel rearing habitat and impair processes that might otherwise create complex habitats along main channel areas. Sudden reductions in outflows below Project dams will, when flows are relatively low, continue to pose risks of juvenile stranding and loss.
- Historically important migratory corridors will continue to be obstructed by Detroit and Big Cliff dams and reservoirs. Under current conditions, and those that will prevail under the Proposed Action, these obstructions preclude the re-establishment of self-sustaining UWR Chinook and UWR steelhead runs in the upper North Santiam subbasin.

In aggregate, these effects will continue to diminish habitat availability and suitability within the North Santiam subbasin for juvenile and adult lifestages of UWR Chinook and UWR steelhead. These adverse effects to the functioning of designated critical habitat within the subbasin will limit the habitat's capacity to serve its conservation role supporting large, productive, and diverse populations of these fish.

Table 5.6-4 Effects of the Proposed Action on populations (VSP column) and Critical Habitat (PCE column) in the North Santiam. Modified from USACE 2007a, Table 6-1

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater migration corridors	Habitat Access	Physical Barriers	Proposed action would continue to limit access to historical habitat for UWR Chinook salmon and UWR steelhead above Big Cliff and Detroit dams.	Upstream passage will continue to be inadequate unless the Action Agencies firmly commit to rebuild Minto trap; downstream passage will continue to kill and injure juvenile fish unless the Action Agencies complete studies and commit to improve survival at the dams to levels comparable to that at other dams in the NW. Fish will continue to lack access to historical habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (flow/hydrology)	Change in Peak/Base Flow	Improved ramping rates and flow conditions below Big Cliff Dam will reduce risks to ESA-listed fish species. The improved ramping and flow conditions could result in improved ecosystem health and function, expanded rearing habitat, higher egg-to-smolt survival, improved migration conditions, and improved overall productivity. As a result, local population abundance also may increase. Biological monitoring will document changes in local habitat conditions and in local population productivity resulting from a combination of Action Agency actions.	Flow-related components of habitat quality for UWR Chinook will be improved in the near-term within areas downriver of the USACE dams in the subbasin. Longer term effects of diminished flood events on channel processes that help create or maintain channel complexity will continue.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Initially, no change in effect from existing unfavorable conditions for spawning, incubation, and emergence of UWR Chinook. If and when WTC capability is developed and implemented, population abundance and productivity would increase. Habitat quality in the natural production area below Foster would improve. Spawning activity and egg-to-fingerling survival is expected to increase for UWR Chinook, resulting in the potential for improved abundance and productivity. Biological monitoring would document realized changes.	Continued adverse effect on spawning and rearing habitat caused by water temperatures released from Project dams that shifts temperatures from natural thermal regime, reducing habitat suitability.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/Turbidity	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical contamination/nutrients	Operation of USACE dams and reservoirs will continue to help dilute pollutants downstream during periods of lowest flow. The consequences of this particular benefit are likely minor relative to the substantially negative effect that unnaturally warm temperatures below Big Cliff and Detroit dams during fall have on the spawning success and emergence timing of UWR Chinook salmon.	No change in effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	Occasional spills may elevate TDG to levels sufficient to harm incubating UWR Chinook embryos in the mainstem North Santiam River below Big Cliff Dam.	Continued unfavorable effect during spill events on spawning/early rearing habitat immediately below Foster Dam.
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing spawning habitat downstream of the canyon below Big Cliff Dam would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available habitat.	Operation of Big Cliff and Detroit dams would continue to block sediment transport to downstream reaches, further increasing substrate coarsening, and thereby degrading limited spawning habitat. Study of gravel augmentation would not guarantee that sediment would be placed below Big Cliff Dam at adequate levels to restore fully functioning habitat.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon and UWR steelhead in the North Santiam Subbasin because holding and rearing habitat below the dams would continue to degrade and would not be replaced.	Operation of Project dams would continue to block transport of large wood from reservoirs to downstream habitat, revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Study of stockpiling LWD would not guarantee new LWD will be placed in reaches below the dams.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Continued degradation of pool habitat would reduce rearing and adult holding habitat, resulting in lowered productivity and abundance	Continued low frequency of pools and poor pool quality downstream of the canyon below Big Cliff Dam. Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance.	Continued reduced off-channel habitat in the North Santiam River downstream of the canyon below Big Cliff Dam and in the mainstem Santiam River. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/Depth Ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider stockpiling LWD for later placement to create habitat complexity and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Degraded streambanks would inhibit channel forming processes that create complex habitat essential for juvenile rearing, adult spawning and holding, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments would continue to prevent streambanks from supporting natural floodplain function downstream of the canyon in the lower North Santiam River below Big Cliff Dam and in the mainstem Santiam River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on the PCES
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance.	Project operation and continued existence and maintenance of revetments would continue to prevent overbank flow and side channel connectivity in the North Santiam River downstream of the canyon below Big Cliff Dam. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, restoring normative ecosystem functions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing, holding, and spawning habitat, resulting in lowered abundance and productivity.	Project operation and continued existence and maintenance of revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the North Santiam River downstream of the canyon below Big Cliff Dam and in the mainstem Santiam River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Chapter 5.7
Molalla Subbasin
Effects

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SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- The effects of the Proposed Action on Molalla populations of UWR Chinook salmon and UWR steelhead would be relatively small compared to baseline conditions, but would contribute to continued degradation of habitat along the mainstem Molalla River, causing minor reduction in abundance and productivity of these two populations and adversely modifying critical habitat. The Proposed Action would result in:
  - Degraded physical habitat elements in the lower Molalla River
  - Continued release of an out-of-basin hatchery Chinook stock from the South Santiam Hatchery resulting in genetic risks to the Molalla Chinook population.

Introduction

For the Molalla River populations of UWR Chinook salmon and UWR steelhead, the Proposed Action includes the following on-the-ground actions:

- Hatchery Program - Release approximately 100,000 hatchery Chinook from South Santiam Hatchery.
- Revetments - Continued existence and maintenance of 2.49 miles of revetments along the Molalla River

In this section, NMFS considers the effects of the Proposed Action on the Molalla UWR Chinook salmon and UWR steelhead populations. In general, NMFS expects that the Proposed Action would cause minor increments of continued degradation of habitat due to ongoing maintenance of revetments, resulting in small reductions in abundance and productivity of these populations. NMFS expects the Proposed Action would have substantial genetic risks to Chinook from the continued release of an out-of-basin hatchery stock. NMFS concludes that the Proposed Action would continue to degrade critical habitat.

5.7.1 Habitat Access & Fish Passage

The Proposed Action would have minimal effect on habitat access and fish passage because there are not Project dams on the Molalla River. However, there are some minor adverse effects due to continued maintenance of revetments precludes fish access to side channels and complex habitat. (See section 5.7.4 below).

5.7.2 Water Quantity/Hydrograph

The Proposed Action would have no effect on water quantity or on the baseline hydrograph in the Molalla subbasin because there are no Project dams on the Molalla River.

5.7.3 Water Quality

The Proposed Action would have a very small adverse effect on the baseline water quality conditions as a result of continued maintenance of 2.49 miles of revetments in the lower Molalla River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, maintenance of revetments would result in small increases in summer water temperatures, particularly in the lower part of the Molalla watershed.

5.7.4 Physical Habitat Quality

The key proposed actions related to physical habitat quality in the Molalla River subbasin that would affect UWR Chinook salmon and UWR steelhead are listed below.

- Continue the existence and maintenance of 2.49 miles of revetments along the Molalla River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.7.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the Molalla River Subbasin

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.7.2.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.7-2 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 2.49 miles of revetments in the lower Molalla River. Although this length comprises a small percentage of the total revetments and length of this stream, the effect of this action will be to continue to restrict channel migration and prevent recruitment of large wood and sediment from streambanks, inhibiting natural processes that create and maintain channel complexity. As described in the baseline section 4.7.3 and 4.7.6, the middle and lower reaches of the Molalla River are more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Molalla populations of UWR Chinook salmon and UWR steelhead in this already impaired habitat.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Molalla subbasin.

In summary, although the revetments maintained by the Action Agencies in the Molalla subbasin are a small percentage of total river length, they would contribute to continued degradation of habitat and would likely cause additional small reductions in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Molalla subbasin.

5.7.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead (section 4.7.2.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.7-2 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 2.49 miles of revetments in the lower Molalla River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to prevent overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Molalla subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Molalla subbasin, would continue to degrade this already impaired habitat, reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Molalla populations of UWR Chinook salmon and UWR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Molalla River subbasin during the term of this Opinion.

In summary, the proposed continued existence and maintenance of revetments in the Molalla River would be a factor in the continued degradation of riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Proposed Action, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Molalla River subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a small reduction in the abundance and productivity of Molalla subbasin populations of UWR Chinook salmon and UWR steelhead.

5.7.5 Hatcheries

The only hatchery fish currently being released into the Molalla River are spring Chinook salmon from the South Santiam hatchery program.

5.7.5.1 Hatchery Operations

There are no hatchery facilities within the Molalla watershed. See the South Santiam hatchery operations section 5.5.5 above for further details on how South Santiam Hatchery is operated.

5.7.5.2 Broodstock Collection

The broodstock used for the Molalla River program is the South Santiam hatchery stock (ODFW stock # 24). See the South Santiam broodstock collection section 5.5.5 for details on how broodstock are collected.

5.7.5.3 Genetic Introgression

The Molalla River historically supported an independent population of spring Chinook salmon. The current wild run is extremely depressed; with most of the Chinook observed on the spawning grounds being of hatchery origin (Table 5.7-1). The current hatchery stock of Chinook released into the Molalla River is from South Santiam Hatchery (an out of population stock). There are two concerns with the current hatchery management within this population. First, since the wild population is extremely depressed, a supplementation hatchery program may be warranted. However, an out-of-population stock is not the best option for supplementation purposes based on the scientific literature (Nickum et al. 2004; Araki et al. 2007). Secondly, if it was desirable to maintain South Santiam hatchery stock releases in the Molalla for harvest augmentation purposes, then the scientific literature recommends that few of these hatchery fish should spawn naturally in the wild (<5% of the population for a segregated hatchery stock; HSRG 2004). Due to the very low numbers of wild fish present in the Molalla River, it would not be possible to reduce hatchery fish spawning to less than 5% of the spawners with current production levels and the harvest regimen.

Table 5.7-1 Spawning ground survey data for Molalla River spring Chinook. Data compiled from Schroeder et al. (2003, 2005) and Schroeder and Kenaston (2004) annual reports.

				Carcasses		% natural-origin Fish (best case scenario)
Year	**Reach**	**Length (mi)**	**Redds**	**No fin clip**[1]	**Finclipped**	
2002	Trout Creek to Old Gawley Creek Bridge	7	16	3	16	0.16
	Old Gawley Bridge to Bull Creek	3.9	22	4	71	0.05
	Bull Creek To Copper Creek	4	11	0	8	0.00
	North Fork: Mile 2 to old 151 Bridge	1.4	3	0	0	NA
	Total	**16.3**	**52**			
2003	Baybarn Creek to Bull Creek	2.3	1	0	0	
	Bull Creek to Old Gawley Bridge	3.9	9	4	12	0.25
	Old Gawley Creek Bridge to Pine Creek Bridge	5.3	5	1	7	0.13
	Total	**11.5**	**15**			
2004	Haybarn Creek to Trout Creek	16.1	44	4	4	.050

5.7.5.4 Disease

Hatchery fish can be agents for the spread of disease to wild fish residing in the natural environment. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the Molalla subbasin, the risk of hatchery Chinook spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts at various locations in the mainstem Molalla River. Significant juvenile fish rearing occurs in the Molalla River. The effects of hatchery fish interacting with other Chinook and steelhead populations downstream are addressed in the section “Mainstem Willamette River”.

Adults
The potential also exists for returning hatchery fish to spread diseases to the few wild adult Chinook commingled in the Molalla River. The risk of hatchery fish spreading diseases in the Molalla is likely to be lower than in other Willamette populations due to the lower numbers of returning adults. However, since the Molalla River gets warmer during the summer months than other rivers, the potential may be exuberated. There is little risk of hatchery Chinook spreading diseases to adult winter steelhead due to the differences in run and spawn timing.

[1] Otoliths have not yet been read to determine the proportion of wild and hatchery fish.

5.7.5.5 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery Chinook are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur over a period of time.

Adults
Given the low returns of hatchery and wild Chinook to the Molalla River, it is unlikely there are competitive interactions for holding and spawning habitat.

5.7.5.6 Predation

It is unlikely that hatchery Chinook have a significant predation impact on wild juvenile Chinook or winter steelhead. It is more likely that wild steelhead would predate upon the hatchery Chinook. There may be a positive benefit to steelhead.

5.7.5.7 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life. Spring Chinook do not have the tendency to residualize like steelhead, thus this risk is deemed to be very low in the Molalla River.

5.7.5.8 Fisheries

As discussed above in Effects section 5.1, “General effects of hatchery programs on ESA-listed salmon and steelhead,” the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural-origin or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (NMFS 2003e). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.7.5.9 Masking

The production of unmarked hatchery fish can have an impact on wild fish if these hatchery fish stray and intermingle with wild populations. Not knowing whether naturally spawning fish are of hatchery- or natural-origin confounds the ability to monitor the true status of the wild population. This effect has been termed “masking” by hatchery fish.

In the Willamette Basin, this concern has been eliminated because all hatchery spring Chinook, summer steelhead, and rainbow trout are all adipose finclipped. In addition, all hatchery spring Chinook are otolith marked in the hatchery which provides an additional safeguard to detect hatchery fish that may have been missed during finclipping (currently <5% of all the smolt releases; McLaughlin et al. 2008). The Action Agencies are also proposing to coded wire tag (CWT) all hatchery spring Chinook salmon, which will also allow individual fish to be identified upon their return to freshwater.

5.7.5.10 Nutrient Cycling

Hatchery fish can provide essential marine-derived nutrients to the freshwater environment if they spawn naturally or are outplanted as carcasses (see “General effects of hatchery programs on ESA-listed salmon and steelhead” section above). Hatchery spring Chinook salmon and summer steelhead are known to spawn naturally throughout the Willamette Basin, thus providing benefits in terms of marine nutrients to the local environment. Thousands of hatchery Chinook are also outplanted alive above the dams in an effort to restore natural production in historic habitats. This provides benefits to aquatic and terrestrial food chains.

5.7.5.11 Monitoring & Evaluation

Monitoring and evaluation of Willamette hatchery programs under the ESA began in response to NMFS (2000a) *Biological Opinion on the impacts from the collection, rearing, and release of listing and non-listed salmonids associated with artificial propagation programs in the Upper Willamette spring Chinook and winter steelhead ESUs.* The ODFW implemented specific monitoring and evaluation activities to collect information on the effects of hatchery programs in the Willamette. This information is summarized in Schroeder et al. (2006) and McLaughlin et al. (2008).

Monitoring and evaluation of hatchery programs in the Willamette Basin will continue to occur in order to assess whether the programs are meeting their intended goals and to evaluate the impacts on wild populations. The specific HGMPs for each program describe the monitoring and evaluation that will occur in the future.

5.7.6 Summary of Effects on Population Traits

The Proposed Action has limited effects in the Molalla subbasin. The primary concern is the continued release of an out-of-basin hatchery Chinook stock in the Molalla. Given that Molalla spring Chinook are currently at very high risk of extinction, the hatchery program should be reformed and/or eliminated. Recent data suggests that the current hatchery program cannot manage hatchery fish spawning to acceptable levels (<5%). Therefore significant hatchery reform actions are necessary to help reduce genetic risks.

The continued existence and maintenance of about 2.49 miles of revetments by the USACE would result in minor effects on UWR Chinook salmon and UWR steelhead. These effects include continued degradation of juvenile rearing and adult holding habitat, resulting in a small reduction in the abundance and productivity of Molalla subbasin populations.

5.7.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Molalla River and a number of its tributaries have been designated as Critical Habitat for UWR Chinook salmon and UWR steelhead. Table 5.7-2 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects of the Proposed Action are attributable to the continuing existence of 2.49 miles of revetments the USACE will maintain along the mainstem Molalla.

The revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent unfavorable temperature increases) and contribute LWD. Across all of the areas affected within the Molalla subbasin and elsewhere, continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook and UWR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.7-2. Effects of the Proposed Action on UWR Chinook salmon and UWR steelhead populations (VSP column) and critical habitat (PCE column) in the Molalla River subbasin.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in peak/base flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor effect of elevated water temperatures could decrease survival and/or growth of juvenile UWR Chinook salmon and steelhead and increase prespawning mortality of adult Chinook and steelhead.	Minor effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, that contribute to elevated summer water temperatures, particularly in the lower part of the Molalla watershed.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Very small effect of Proposed Action on substrate in the Molalla that prevents formation of new gravels, but lower Molalla not historically used for spawning, and thus effect is mainly to reduce invertebrate productivity on which rearing fish feed. Minimal reduction in abundance and productivity of Molalla populations of UWR Chinook salmon and UWR steelhead due to small length of revetment in the Molalla.	Continued existence and maintenance of 2.49 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause small reduction in abundance and productivity of UWR Chinook salmon in the Molalla subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 2.49 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Molalla River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued low frequency of pools in lower Molalla River. Continued existence and maintenance of 2.49 miles of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would contribute to continued reduced off-channel habitat in the lower Molalla River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead	Continued existence and maintenance of 2.49 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Molalla River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Molalla River during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Molalla River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, furthering limiting juvenile rearing and adult holding habitat, resulting in small reduction in productivity and abundance of Molalla populations of UWR Chinook salmon and steelhead.	Continued existence and maintenance of 2.49 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Molalla River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Molalla subbasin.

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Clackamas Subbasin Effects

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5.8 CLACKAMAS SUBBASIN

SUMMARY OF THE EFFECTS WITHIN THE CLACKAMAS SUBBASIN OF THE PROPOSED ACTION ON LISTED SALMON & STEELHEAD POPULATIONS

- The Proposed Action would continue the existence and maintenance of about 1.6 miles of revetments along the lower Clackamas River. When repairs to these revetments occur, direct effects on the subbasin's populations of UWR Chinook, LCR Chinook, LCR Coho, and LCR steelhead would be minor, and there would be small, indirect adverse effects on the habitat of these fish. These adverse effects would be relatively small compared to baseline conditions, but would contribute to continuing losses of habitat function along the mainstem Clackamas River, and to the diminished abundance and productivity of the four populations identified.

Introduction

Within the Clackamas subbasin the Proposed Action includes the following action:

- Revetments – Continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River.

In this section, NMFS considers the effects of the Proposed Action within the Clackamas subbasin on UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead, and critical habitat. In general, NMFS expects that the Proposed Action would cause minor degradation of habitat due to continued existence and maintenance of revetments, resulting in small reductions in abundance and productivity of the populations of these fish found in the Clackamas subbasin.

5.8.1 Habitat Access & Fish Passage

The Willamette Project does not affect habitat access or fish passage within the Clackamas subbasin.

5.8.2 Water Quantity/Hydrograph

The Willamette Project has no effect on streamflows within the Clackamas subbasin.

5.8.3 Water Quality

The Proposed Action would have a very small effect on water quality conditions as a result of continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River. By reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, the revetments would result in small increases in summer water temperatures in the lower Clackamas River.

The Proposed Action would also have minor, short-term effects on the turbidity of the lower Clackamas River should repairs be needed at the USACE revetments. Such repairs would be subject to additional environmental review and appropriate mitigation measures, and thus unlikely to cause reductions in water quality sufficient to harm listed anadromous salmonids.

5.8.4 Physical Habitat Quality

Proposed actions related to physical habitat quality in the Clackamas subbasin that would affect UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and UWR steelhead are listed below.

- Continued existence and maintenance of 1.6 miles of revetments along the lower Clackamas River, preventing channel migration and reducing channel complexity.
- Study effects of Project revetments on downstream habitat and consider projects to restore habitat, if authorized and funding becomes available.

5.8.4.1 Substrate, Sediment Transport, Large Wood, & Channel Complexity

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for ESA-listed anadromous salmonids (Section 4.8.6). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.8-1 (end of this section, 5.8) and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 1.6 miles of revetments on the lower Clackamas River. Although this length comprises only a small portion of the total revetments and length of this stream, this action would continue to restrict channel migration and prevent recruitment of large wood and sediment from streambanks, inhibiting natural processes that create and maintain channel complexity. As described in the baseline section 4.8.3.4, the lower Clackamas River is more heavily impacted by land use practices, including channelization and revetments, that have caused coarsening and siltation of substrate, low levels of large wood, and reduced channel complexity. The Proposed Action would cause minor reductions in juvenile rearing and adult holding habitat, further limiting abundance and productivity of the Clackamas populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead.

The Action Agencies propose to conduct a general study of USACE revetments in the Willamette basin, including consideration of habitat restoration projects, but the Action Agencies do not propose specific measures that would restore large wood, sediment transport, and channel complexity in the Clackamas subbasin.

In summary, although the revetments maintained by the Action Agencies in the Clackamas subbasin are a small percentage of total river length, they would contribute to a continued loss of habitat function and would likely cause a minor reduction in the carrying capacity of this habitat for rearing juvenile fish and holding adults, thus reducing the number of individual ESA-listed salmonids that can be produced in this presently degraded habitat. Aside from unspecified habitat restoration actions that may result from proposed habitat and revetment studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the Clackamas subbasin.

5.8.4.2 Riparian Vegetation & Floodplain Connectivity

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and limit rearing and holding habitat for UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead (section 4.8.3.4). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.8-1 and described below.

Under the Proposed Action, the Action Agencies would continue the existence and maintenance of about 1.6 miles of revetments in the lower Clackamas River. Although this length of revetments comprises a small percentage of the total revetments and length of this stream, this action would continue to prevent overbank flows, river migration, and contribution of sediment and large wood from streambanks. Infrequent inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles. Additionally, the Proposed Action would continue to prevent establishment of riparian vegetation in the lower Clackamas subbasin by interfering with the processes needed for new floodplain forests to establish. The reduced extent of riparian vegetation and lack of floodplain connectivity hinders recruitment of large wood into the aquatic system and reduces off-channel refugia, both habitat features needed to create resting pools for migrating adults and provide cover for rearing juveniles. The Proposed Action, although limited in extent in the Clackamas subbasin, would continue to degrade this already impaired habitat, further reducing juvenile rearing and adult holding habitat, with minor effects on abundance and productivity of the Clackamas populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead. Although the Proposed Action includes study of revetments in the Willamette basin and potential habitat restoration, there is no certainty that any restoration work would be done in the Clackamas subbasin during the term of this Opinion.

In summary, the continued existence and maintenance of revetments in the Clackamas River under the Proposed Action would have a negative effect by continuing to degrade riparian and floodplain forests and floodplain connectivity. Aside from unspecified habitat restoration actions that may result from revetment and habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the Clackamas subbasin. Continued degradation of juvenile rearing and adult holding habitat under the Proposed Action would cause a very small reduction in the abundance and productivity of Clackamas subbasin populations of UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead.

5.8.5 Hatcheries

The Proposed Action includes no hatchery programs in the Clackamas subbasin, but adult salmon and steelhead of hatchery origin from USACE programs upstream of Willamette Falls may stray into the natural spawning areas of the UWR Chinook salmon and LCR steelhead populations in the subbasin. To the degree that this occurs and that the stray spawners are successful at spawning in the wild, such straying would likely have a small, adverse effect on the abundance and productivity of the affected ESA-listed populations.

5.8.6 Summary of Effects on ESA-Listed Anadromous Fish Populations in the Clackamas River Subbasin

The Proposed Action would have limited effects on ESA-listed salmonids within the Clackamas subbasin, as summarized in Table 5.8-1. Continued existence and maintenance of about 1.6 miles of revetments would result in minor adverse effects on UWR Chinook, LCR Chinook, LCR Coho, and LCR steelhead. These effects include continued degradation of juvenile rearing and adult holding habitat, resulting in very small reductions in the abundance and productivity of Clackamas subbasin populations.

5.8.7 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Clackamas River and many of its tributaries have been designated as Critical Habitat for UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, and LCR steelhead. Table 5.8-1 identifies the anticipated effects of the Proposed Action on the PCEs of this habitat. All of the effects are attributable to the continued existence and maintenance of 1.6 miles of revetments along the mainstem Clackamas by the USACE.

The USACE revetments limit natural channel migration and the formation of complex and diverse salmonid habitats, including off-channel areas that are particularly important to juvenile fish during periods of high winter flows. They also impede the establishment and growth of riparian vegetation that might otherwise provide shade (to prevent adverse temperature increases) and contribute LWD. Across all of the areas affected within the Clackamas subbasin and elsewhere, continued existence and maintenance of these structures will continue to assure diminished habitat suitability for multiple lifestages of UWR Chinook, LCR Chinook, LCR coho salmon, and LCR steelhead, and to limit the habitat's capacity to support large and productive populations of these fish.

Table 5.8-1 Effects of the Proposed Action on ESA-listed anadromous salmonid populations (VSP column) and critical habitat (PCE column) in the Clackamas River subbasin.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in peak/base flow	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	Minor adverse effect of elevated water temperatures could effect a very small decrease survival and/or growth of juvenile UWR Chinook salmon, LCR Chinook salmon, LCR coho, or LCR steelhead and increase pre-spawning mortality of adult Chinook.	Minor adverse effect of revetments, by reducing riparian vegetation and stream processes that enable formation of complex habitats and deep pools, which contributes to elevated summer water temperatures in the lower Clackamas River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Suspended Solids/ Turbidity	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination /Nutrients	No effect	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total Dissolved Gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Very small adverse effect of Proposed Action on substrate in the Clackamas that prevents formation of new gravels for spawning. Very small reduction in abundance and productivity of Clackamas populations of UWR Chinook salmon, LCR Chinook, LCR coho, and LCR steelhead due to small length of revetment in the Clackamas.	Continued existence and maintenance of 1.6 miles of revetments would prevent channel migration, limiting production of new gravel bars and substrate.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large Woody Debris	Very small effect of Proposed Action on continued lack of large wood; would cause very small reduction in abundance and productivity of ESA-listed salmonid populations in the Clackamas subbasin because adult holding and juvenile rearing habitat would continue to degrade and would not be replaced.	Continued existence and maintenance of 1.6 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools. Habitat restoration studies would not guarantee new LWD would be placed in the Clackamas River.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	Very small effect of Proposed Action on continued degradation of pool habitat; would cause small reduction in rearing and adult holding habitat, resulting in very small reduction in productivity and abundance of ESA-listed salmonid populations.	Continued diminished frequency of pools in lower 1.6 miles of revetments would continue to prevent channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat Elements	Off-channel Habitat	Very small effect of Proposed Action on continued lack of off-channel habitat, which would cause small reduction in juvenile refugia and rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would contribute to continued reduced off-channel habitat along the lower Clackamas River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth ratio	Very small effect of Proposed Action on continued degradation of width/depth ratio; would cause small reduction in rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to facilitate channel cutting and deepening, reducing width/depth ratio and limiting formation of complex habitats. Although studies may consider habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	Very small effect of Proposed Action on streambank condition, by inhibiting channel forming processes that create complex habitat essential for juvenile rearing and adult holding; would result in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead	Continued existence and maintenance of 1.6 miles of revetments would continue to prevent streambanks from supporting natural floodplain function in the lower Clackamas River. Although studies may consider habitat restoration projects to improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out in the Clackamas River during the term of this Opinion.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	Very small effect of Proposed Action on continued lack of floodplain connectivity reduces availability of off-channel habitat, which would cause small reduction in available refugia and juvenile rearing habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to prevent overbank flow and side channel connectivity in the lower Clackamas River. Although studies may consider habitat restoration projects that could provide access to off-channel habitat, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	Very small effect of Proposed Action on continued degradation of riparian forests, which would cause small reduction in large wood recruitment, further limiting juvenile rearing and adult holding habitat, resulting in very small reduction in productivity and abundance of Clackamas populations of ESA-listed salmon and steelhead.	Continued existence and maintenance of 1.6 mi. of revetments would continue to constrain the channel and prevent overbank flow, limiting extent and quality of riparian forests in the lower Clackamas River. Although studies may consider habitat restoration projects that could potentially restore riparian vegetation, the Action Agencies provide no certainty that such projects would be funded and carried out in the Clackamas subbasin.

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Chapter 5.9
Coast Fork Willamette & Long Tom Subbasins Effects

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5.9 COAST FORK WILLAMETTE & LONG TOM SUBBASINS

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- Coast Fork Willamette Subbasin: The Proposed Action would result in continued degradation of juvenile rearing and refugia habitat in lower reaches of the Coast Fork Willamette River, causing relatively minor decline in abundance and productivity of Middle Fork Willamette and McKenzie populations of UWR Chinook salmon.
- Long Tom Subbasin: The Proposed Action would result in continued degradation of juvenile rearing and refugia habitat in lower reaches of the Long Tom River, causing relatively minor decline in abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations of UWR Chinook.

Introduction/Populations Affected

Coast Fork Willamette Subbasin

Although UWR Chinook salmon were likely once produced naturally in the Coast Fork Willamette, the WLCTRT did not identify these fish as a historical demographically independent population (Myers et al. 2006). However, in multiple years since 1998, ODFW has released adult Chinook salmon from the Willamette Hatchery into Mosby Creek, a tributary of the Row River in the Coast Fork Willamette subbasin. The effectiveness of this release has not been determined, though initial monitoring indicates high pre-spawning mortality (Moberly 2008).

Steelhead were not historically produced in the Coast Fork Willamette, and the WLCTRT did not identify a demographically independent population of UWR steelhead in this subbasin.

Long Tom River Subbasin

The WLCTRT did not identify demographically independent populations of UWR Chinook salmon or UWR steelhead in this subbasin. However, based on catches of juvenile Chinook in screw traps in the lower Long Tom River (Schroeder and Kenaston 2004), some juvenile UWR Chinook salmon from the Middle Fork Willamette (including Fall Creek) and McKenzie subbasins probably overwinter in the lower Long Tom River (section 4.9.2.1). Juvenile Chinook salmon have been caught in screw traps in the lower reach of the Long Tom during winter (Schroeder and Kenaston 2004).

UWR Chinook salmon and UWR steelhead are likely to be affected by the following elements of the Proposed Action:

Coast Fork Willamette

- Current configuration, continued operation, and maintenance of Dorena and Cottage Grove dams in the Row River and upper Coast Fork Willamette River, respectively.
- Revetments – continued maintenance of 4.26 mi. of revetments along the Coast Fork Willamette River and 0.43 mi. in the Row River.

Long Tom subbasin

- Current configuration, continued operation, and maintenance of Fern Ridge Dam and other several other small dams in the Long Tom River.

In this section, NMFS considers the effects of the Proposed Action on UWR Chinook salmon and UWR steelhead that occupy the Coast Fork Willamette and Long Tom for portions of their life cycles. NMFS expects that the Proposed Action would cause continued degradation of habitat downstream of the dams. However, because there are no independent populations of either Chinook salmon or steelhead in these subbasins, the effects on listed populations would be limited to reducing juvenile rearing/overwintering habitat for McKenzie, Calapooia, and Middle Fork Willamette populations of UWR Chinook. Because no critical habitat was designated for listed salmonid populations in the Long Tom and Coast Fork Willamette subbasins, the Proposed Action would not affect PCEs in these subbasins.

5.9.1 Habitat Access & Fish Passage

Coast Fork Willamette River Subbasin

Cottage Grove and Dorena dams prevent access to 80 miles of historic habitat (USACE 2000, 5-72). However, because Chinook salmon and steelhead were virtually extirpated from this basin prior to Project construction, neither dam was constructed with fish passage facilities. Under the Proposed Action, the Action Agencies would include an assessment of fish passage feasibility at these dams in the Willamette System Review Study (USACE 2007a, p. 3-138). Given the existing problems with mercury contamination (see section 4.9.3.3.6) in the reservoirs and habitat further upstream and NMFS' determination that the Coast Fork does not support a demographically independent population of Chinook salmon or steelhead, fish passage and access to historic habitat in this subbasin is a low priority for actions to increase the viability of UWR Chinook salmon.

In summary, the effect of the Proposed Action on habitat access in the Coast Fork for UWR Chinook salmon is negligible. In the future, if NMFS were to determine that the Coast Fork should be used to reestablish a population of UWR Chinook salmon, then Project effects on habitat access in the Coast Fork would be reassessed.

Long Tom River

Although there are no passage facilities at Fern Ridge Dam on the Long Tom River, the project does not block access to historic habitat for UWR Chinook salmon (individual Chinook salmon are known to use only the lower reaches of the Long Tom River for juvenile rearing/overwintering). UWR Chinook and UWR steelhead have never made much use of this river due to high summer water temperatures (USACE 2000, p. 5-78; USACE 2007a, p. 5-36). Thus, the Proposed Action on the Long Tom River would have little effect on UWR Chinook or UWR steelhead.

Summary

The Proposed Action would not adversely affect fish passage in the Coast Fork Willamette and Long Tom subbasins

5.9.2 Water Quantity/Hydrology

Coast Fork Willamette River Subbasin

Under the Proposed Action, the Dorena and Cottage Grove projects would continue to be used for flood control and to meet mainstem Willamette flow objectives at Albany and Salem. These operations would reduce the magnitude and frequency of peak flows in the Row and Coast Fork Willamette rivers, simplifying the channel and restricting connectivity to the floodplain, which in turn would reduce refugia and complex habitat for juvenile UWR Chinook salmon that use lower reaches of the Coast Fork Willamette River near its mouth. However, because this habitat is used for a short duration by individuals of the Middle Fork Willamette and McKenzie populations, NMFS expects the effect of this habitat degradation and loss to be relatively small compared to adverse effects of similar elements of the Proposed Action in eastside subbasins.

Long Tom River Subbasin

Under the Proposed Action, Fern Ridge Dam would continue to be used for flood control and to meet mainstem flow objectives. These operations would reduce the magnitude and frequency of peak flows in the Long Tom River, simplifying the channel and restricting connectivity to the floodplain, which in turn, would reduce refugia and complex habitat for juvenile UWR Chinook salmon rearing in lower reaches of the Long Tom River. However, because this habitat tends to be used seasonally by individual fish (most likely from Middle Fork Willamette, Calapooia, and McKenzie UWR Chinook salmon populations), NMFS expects the effect of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins.

5.9.3 Water Quality

Water Temperature

Coast Fork Willamette River Subbasin

Under the Proposed Action, no changes would be made to the structure or operation of Dorena or Cottage Grove dams to restore normative water temperatures downstream (described in Baseline section 4.9.3.3.1). Thus, the effect of the proposed action would be to maintain the current degraded water temperature condition, limiting the value of the lower reaches of the Coast Fork Willamette and Row rivers as potential spawning habitat for UWR Chinook salmon.

Long Tom River Subbasin

Under the Proposed Action, no changes would be made to the structure or operation of Fern Ridge Dam to restore normative water temperatures downstream (described in Baseline section 4.9.3.3.1). Thus, the effect of the proposed action would be to maintain the current degraded water temperature condition.

Some juvenile UWR Chinook overwinter in the lower Long Tom before emigrating from the system the following spring. The ODEQ (2002) CWA 303(d) database indicates that temperatures are within recommended limits for salmonid rearing during the winter period.

5.9.4 Physical Habitat Quality

5.9.4.1 Large Wood, Sediment Transport, & Channel Complexity

Coast Fork Willamette Subbasin
As described in section 4.9.3.4, operation of Cottage Grove and Dorena dams has trapped gravel and large wood from 50% of the subbasin and has reduced the magnitude of peak flows in the Coast Fork Willamette subbasin. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, side channels, and pools, which provide habitat for rearing and migrating anadromous salmonids. Additionally, the continued maintenance of USACE revetments would prevent river migration and sediment contribution from 4.26 miles of streambank in the lower Coast Fork Willamette, further depriving the river of sediment and the natural ability to restore complex channels with diverse habitat features. Andrus and Walsh (2002) reported a 69% decrease in gravel bars in the lower 4 miles of the Coast Fork Willamette River.

Under the Proposed Action, operation of Dorena and Cottage Grove dams and maintenance of 4.26 miles of revetments would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of creating new bars, side channels, and pools. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Coast Fork Willamette River near its mouth. However, because this habitat appears to be used only seasonally during winter (most likely by individuals from Middle Fork Willamette and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose measures that would restore large wood, sediment, and channel complexity in the Coast Fork subbasin.

Long Tom Subbasin
As described in sections 4.9.3.4, operation of Fern Ridge Dam in the Long Tom has trapped gravel and large wood from 60% of the subbasin and has reduced the magnitude of peak flows in the subbasin. Both of these operations deprive downstream reaches of bed material and transport mechanisms needed to create new gravel bars, islands, side channels, and pools, which provide habitat for rearing salmonids.

Under the Proposed Action, operation of Fern Ridge Dam would continue to store sediment and large wood in the reservoir, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and diminish high flows that might otherwise be capable of creating new bars, side channels, and pools. This would result in reduced amount and quality habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Long Tom River. However, because this habitat is used seasonally (most likely by individuals from Middle Fork Willamette, Calapooia and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration

Study, the Action Agencies do not propose any measures that would restore large wood, sediment, and channel complexity in the Long Tom subbasin.

5.9.4.2 Riparian Vegetation & Floodplain Function

Coast Fork Willamette Subbasin

As described in the previous subsection (5.9.4.1), operation of Cottage Grove and Dorena dams has trapped gravel and large wood and reduced peak flows in the Coast Fork and Row rivers. Together with maintenance of 4.26 miles of revetments in the lower Coast Fork Willamette River, these actions restrict new gravel bar formation and floodplain surfaces, on which riparian vegetation can become established, and reduce inundation of forested floodplains, limiting the availability of high-water refugia for juveniles.

Under the Proposed Action, operation of Cottage Grove and Dorena dams and maintenance of revetments would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of inundating floodplains and creating new bars and islands on which vegetation can establish. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Coast Fork Willamette. However, because this habitat is used only seasonally (most likely by individual fish from Middle Fork Willamette and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would riparian vegetation and floodplain function in the Coast Fork Willamette subbasin.

Long Tom Subbasin

Operation of Fern Ridge Dam has trapped gravel and large wood and reduced peak flows in the Long Tom River subbasins. This has limited formation of new gravel bars and floodplain surfaces on which riparian vegetation can become established and reduced inundation of forested floodplains, limiting the availability of high-water refugia for juveniles.

Under the Proposed Action, operation of Fern Ridge Dam would continue to store sediment and large wood in the reservoirs, prevent recruitment of large wood and sediment from streambanks, allow stabilization of formerly active bar surfaces, and prevent flows capable of inundating floodplains and creating new bars and islands on which vegetation can establish. This would result in reduced amount and quality of habitat for juvenile UWR Chinook salmon that rear in lower reaches of the Long Tom River. However, because this habitat is used only seasonally (most likely by individual fish from Middle Fork Willamette, Calapooia and McKenzie UWR Chinook salmon populations), NMFS would expect the effects of this habitat degradation and loss to be relatively small compared to effects of similar elements of the Proposed Action in eastside subbasins. Aside from unspecified habitat restoration actions that are expected to result from the Willamette Floodplain Restoration Study, the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain function in the Long Tom subbasin.

5.9.5 Hatcheries

There are no hatchery facilities or hatchery fish releases in the Coast Fork Willamette and Long Tom subbasins, with the exception of a few adult Chinook salmon outplants in Mosby Creek in the Coast Fork Willamette subbasin). All hatchery fish releases occur in the Middle Fork, McKenzie, South Santiam, North Santiam, and Molalla rivers. All hatchery Chinook salmon and summer steelhead are released as smolts. The intent is for these hatchery fish to actively emigrate to the ocean, thus minimizing the period of time hatchery fish are potentially interacting with naturally rearing listed fish downstream of the hatcheries. It is very unlikely any of the hatchery Chinook or summer steelhead would migrate into the Coast Fork Willamette and Long Tom subbasins and interact with any listed fish that may be present.

5.9.6 Summary of Effects on ESA-Listed Anadromous Fish in the Coast Fork Willamette & Long Tom Subbasins

Table 5.9-1 summarizes anticipated effects of the Proposed Action on ESA-listed anadromous salmonids within the Coast Fork and Long Tom subbasins. The Proposed Action would have small adverse effects within the lower Coast Fork and Long Tom subbasins on fish from the Middle Fork Willamette, McKenzie, and Calapooia populations of UWR Chinook. These effects would result from continued reductions in the amount and quality of habitat for rearing/overwintering of UWR Chinook below dams in the lower reaches of each system. The result would be a continuation of minor, unquantifiable reductions in abundance, productivity, diversity, and spatial structure for the identified populations.

5.9.7 Effects of the Proposed Action on Designated Critical Habitat

NMFS did not designate critical habitat in the Coast Fork Willamette or Long Tom subbasins.

Table 5.9-1 Effects of the Proposed Action on abundance, productivity, spatial structure, and/or diversity of UWR Chinook in the Coast Fork Willamette and Long Tom subbasins.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater migration corridors	Habitat Access	Physical Barriers	No effect
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quantity (Flow/ Hydrology)	Change in Peak/Base flow	*Coast Fork and Long Tom*: Project dams would continue to alter hydrology and reduce peak flows, limiting off-channel refugia for UWR Chinook that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Temperature	*Coast Fork and Long Tom*: Project dams would continue to affect temperatures in the lower Coast Fork and Row rivers, contributing to an unfavorable spawning environment for UWR Chinook. Juvenile UWR Chinook from populations that spawn in nearby subbasins may rear near mouths of these tributaries, but Project effects on stream temperatures there would have limited effect on the abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total suspended Solids/ Turbidity	No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Chemical Contamination/ Nutrients	*Coast Fork:* Project dams would continue to block mercury transport from upstream mine tailings and sediment deposits. Mercury levels in UWR Chinook salmon rearing in lower river may be above normal but would have minor effect on the abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations. *Long Tom:* No effect.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Dissolved Oxygen (DO)	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water Quality	Total Dissolved Gas (TDG)	No effect
Freshwater spawning sites	Habitat elements	Substrate	*Coast Fork and Long Tom*: Project dams would continue to block sediment transport, reducing quality and quantity of rearing habitat for UWR Chinook juveniles that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Large Woody Debris (LWD)	*Coast Fork and Long Tom*: Project dams would continue to block large wood, reducing quality and quantity of complex rearing habitat for UWR Chinook juveniles that may rear near mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	**Pathway**	**Indicator**	**Effects on VSP Parameters**
Freshwater rearing sites Freshwater migration corridors	Habitat Elements	Pool Frequency and Quality	*Coast Fork and Long Tom*: Project dams would continue to block large wood and sediment, reducing pool frequency and quality used as rearing habitat by UWR Chinook juveniles near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	*Coast Fork and Long Tom*: Proposed Action would continue to block large wood and sediment, reducing off-channel habitat used as refugia by UWR Chinook juveniles near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing	Channel Conditions and Dynamics	Width/depth Ratio	*Coast Fork and Long Tom*: Proposed Action would continue to restrict channel forming processes, reducing width/depth ratio, and limiting complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Streambank Condition	*Coast Fork and Long Tom*: Proposed Action would continue to restrict channel forming processes, increasing streambank armoring and resulting in habitat simplification, thus limiting complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater rearing Freshwater migration corridors	Channel Conditions and Dynamics	Floodplain Connectivity	*Coast Fork and Long Tom*: Proposed Action would continue to restrict floodplain connectivity, limiting refugia and complex habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed Conditions	Riparian Reserves	*Coast Fork and Long Tom*: Proposed Action would continue to reduce riparian reserves, limiting habitat used by UWR Chinook juveniles rearing near the mouths of these tributaries, but would have limited effect on abundance and productivity of Middle Fork Willamette, McKenzie, and Calapooia populations.

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Chapter 5.10
Mainstem Willamette Effects

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5.10 MAINSTEM WILLAMETTE RIVER: EFFECTS OF THE WILLAMETTE PROJECT PROPOSED ACTION ON UWR CHINOOK SALMON, UWR STEELHEAD, LCR CHINOOK SALMON, LCR STEELHEAD, LCR COHO SALMON & INTERIOR SPECIES USING THE MAINSTEM WILLAMETTE RIVER

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- The effects of the Proposed Action in the mainstem Willamette River on populations of UWR Chinook salmon and UWR steelhead above the Falls will be that baseline conditions will generally continue, causing further decline in these populations. The Proposed Action will continue to:
  - Reduce the frequency and magnitude of peak flows, reducing floodplain connectivity, riparian forests, and habitat complexity in the mainstem Willamette River above the Falls, and to a lesser extent near the mouth.
  - Eliminate sediment and large wood transport from 27% of the watershed and restrict channel movement with revetments, degrading substrate, large wood, and channel complexity in the mainstem Willamette above the Falls, and to a lesser extent near the mouth.
  - Improve water quality in the mainstem Willamette above and below the Falls, by maintaining flows at Salem, Oregon to meet NPDES standards and by maintaining spring flows at Willamette Falls of around 15,000 cfs (see Table 5.10-2) to provide safe passage for steelhead smolts.
- For populations of UWR chinook and steelhead below the Falls, as well as LCR chinook, coho salmon, and steelhead and Interior species that may use the lower Willamette River near the mouth for rearing and holding, the Proposed Action may harm individual fish by continuing to degrade rearing and holding habitat, but not to the extent that NMFS expects effects at the population level for any of these populations.

In this section, the mainstem Willamette River is considered in two geographical reaches: above Willamette Falls (Falls) at RM 26.6 upstream to the confluence of the Coast Fork and Middle Fork Willamette rivers, and below the Falls downstream to the mouth at the confluence with the Columbia River. Although there are no separate populations of listed salmonids designated for the mainstem Willamette River, all of the salmonid populations and ESUs considered in this Opinion use these reaches to varying extents for parts of their life cycles and are potentially affected by the Proposed Action in these reaches. Table 5.10-1 identifies which reaches of the mainstem Willamette are used by each population.

Table 5.10-1 Listed salmonid populations that use reaches of the mainstem Willamette River.

ESU/DPS	Population	Mainstem Willamette River above Willamette Falls	Mainstem Willamette River below Willamette Falls or near mouth
UWR Chinook salmon	Middle Fork Willamette	X	X
UWR Chinook salmon	McKenzie	X	X
UWR Chinook salmon	Calapooia	X	X
UWR Chinook salmon	North Santiam	X	X
UWR Chinook salmon	South Santiam	X	X
UWR Chinook salmon	Molalla		X (primarily)
UWR Chinook salmon	Clackamas		X
UWR steelhead	Calapooia	X	X
UWR steelhead	North Santiam	X	X
UWR steelhead	South Santiam	X	X
UWR steelhead	Molalla		X
UWR steelhead	Westside tribs		X
UWR steelhead	Clackamas		X
LCR Chinook salmon	Clackamas		X
LCR coho salmon	Clackamas		X
LCR steelhead	Clackamas		X
Other LCR populations[1]			X
Interior ESUs/DPSs[2]			X

Notes:

1 Only LCR populations that spawn in tributaries of the Columbia River upstream of Willamette River (LCR Chinook salmon, LCR coho, LCR steelhead, and Columbia River Chum)

2 "Interior ESUs/DPSs" as used in this Opinion means UCR Chinook salmon, UCR steelhead, MCR steelhead, SR spring/summer chinook salmon, SR fall chinook salmon, SR sockeye salmon, SR steelhead, and CR chum salmon.

The Proposed Action includes the following actions that would be likely to affect listed fish populations using the mainstem Willamette River for juvenile rearing, adult holding, and migration:

- Project dams: continued operation and maintenance under existing configuration of 13 Project dams in major tributaries of the Willamette River.
  - Flow Management - targets for mainstem Willamette River and tributary minimum flows and releases from Project dams to attempt to meet these targets.
  - Ramping Rates - targets that control how quickly water releases from Project dams are increased or decreased.
  - Flow-related RM&E measures.

- Revetments: continued existence and maintenance of 22.68 miles of revetments along the mainstem Willamette River.
- Hatchery program: continued production of hatchery Chinook and summer steelhead that contribute to recreational fisheries in the mainstem.
- Water contract program: continued issuance of contracts by Reclamation for withdrawal of stored water from major tributaries and mainstem for irrigation use.

In this section, NMFS considers the effects of the Proposed Action on populations of UWR Chinook salmon, UWR steelhead, LCR Chinook salmon, LCR coho salmon, LCR steelhead, and the Interior species that use the mainstem Willamette River. In general, the Proposed Action would cause continued degradation of habitat in the mainstem Willamette above Willamette Falls, and to a lesser extent below the Falls near the mouth. This habitat degradation would continue at about the same rate as in recent baseline years and would likely reduce habitat available for juvenile rearing and adult holding primarily for the UWR Chinook and UWR steelhead populations above the Falls, reducing abundance and productivity of these populations. The Proposed Action would continue to harm fish in the mainstem Willamette River above the Falls such that UWR Chinook salmon populations from the Middle Fork Willamette, Calapooia, McKenzie, North and South Santiam, and Molalla rivers and UWR steelhead populations from the North and South Santiam and Calapooia rivers would continue to decline and critical habitat will continue to be adversely affected as a result of the Proposed Action. Anadromous fish in the other ESUs and DPSs below the Falls may also be harmed as a result of the Proposed Action, but to a lesser extent, likely not enough to reduce abundance and productivity of these other populations. (See Table 5.10-3)

5.10.1 Habitat Access & Fish Passage

The Proposed Action would not affect fish passage at barriers on the mainstem Willamette because there are no federal dams on the mainstem. The effects of reservoir water storage and Project flow releases on fish migration are discussed in section 5.10.2.

5.10.2 Water Quantity/Hydrograph

Under the Proposed Action, flow and hydrology would continue not providing properly functioning habitat for UWR Chinook salmon and UWR steelhead (Section 4.10.3.2) in the mainstem Willamette River.

The Action Agencies propose to continue flow management as conducted since 2000. This includes attempting to meet specified seasonal minimum flows at Salem. Thus, the hydrologic effects of the Proposed Action would be the same as those described under the environmental baseline for the mainstem Willamette River (Section 4.10.3.2). These effects are described in the following sections. NMFS does not anticipate that the flow management activities within the Proposed Action would harm the other ESUs (LCR and Interior species) or adversely modify critical habitat designated for those species, except to the extent that reduced peak flows limit physical habitat values described in section 5.10.4 below.

5.10.2.1 Seasonal Flows

Under the Proposed Action, the Willamette Project would continue to reduce spring flows as the storage reservoirs are refilled. The significance of this flow reduction varies with the prevailing hydrologic conditions during individual years (e.g., wet, dry, or average). The primary effect of reducing spring flows in the mainstem Willamette River would be a decrease in the survival of outmigrating juvenile UWR steelhead. Steelhead juvenile survival in the Willamette River is known to be affected by water temperatures which are increased by reducing flows.

To mitigate these effects, the Action Agencies propose to manage system releases to provide a high probability of maintaining minimum flows at Salem known to benefit juvenile UWR steelhead survival (Table 5.10-2). This proposal represents a substantial improvement in the protection of UWR steelhead over conditions that occurred prior to 2000, and a continuation of favorable flow conditions in place since that time. However, the frequency of achieving these flows is reduced by Project refill operations.

Table 5.10-2 Mainstem Willamette Flow Objectives

Time Period	7-Day Moving Average 1 Minimum Flow at Salem (cfs)	Instantaneous Minimum Flow at Salem (cfs)	Minimum Flow at Albany (cfs) 2
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500 2
June 16 - 30	8,700	7,000	4,500 2
July 1 – 31	---	6,000 1	4,500 2
August 1 – 15	---	6,000 1	5,000 2
August 16 – 31	---	6,500 1	5,000 2
September 1 – 30	---	7,000 1	5,000 2
October 1 – 31	---	7,000	5,000

[1] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.
[2] Congressionally authorized minimum flows (House Document 531). September flows were extended into October.

5.10.2.2 Frequency of Channel-Forming & Over-Bank Flows

By continuing to reduce the frequency of channel-forming and over-bank flows in the mainstem Willamette River through flood-control operations, the Willamette Project would continue to limit channel complexity and thereby limit rearing habitat for juvenile UWR Chinook salmon and UWR steelhead. Rearing juvenile spring Chinook salmon and steelhead are known to use the mainstem Willamette River for rearing in all months. The channel simplifying effects of peak flow reduction (e.g., loss of side channels and floodplain connectivity, loss of low velocity habitats, and loss of riparian community complexity) are expected to continue and may worsen over the life of the Proposed Action as land development expands into the river's floodplain. These channel simplifying effects would be exacerbated by continued existence and maintenance of channel revetments and levees (see section 5.10.4).

The Proposed Action includes studies intended to identify opportunities to modify project operations to enhance tributary ecosystem function, including channel forming functions. To the extent that any future modification of project operations undertaken to improve tributary channel function results in improved mainstem channel complexity, benefits would likely accrue to UWR Chinook and steelhead juveniles and their critical rearing habitats.

5.10.2.3 Flow Fluctuations

Due to the size of the mainstem Willamette River and the distance from Project dams, it is unlikely that project operations currently cause substantial flow fluctuations in the mainstem Willamette River and resulting entrapment and stranding events. This would continue under the Proposed Action.

5.10.2.4 Water Use on the Mainstem Willamette River

Under baseline conditions, there are a total of 49 long-term Reclamation stored water contracts in effect to divert stored water from Project dams at sites along the mainstem Willamette River. Cumulatively, these 49 contracts can withdraw a maximum of 10,971 acre-feet of stored water for irrigation.

In addition, there are 35 applications pending for stored water contracts to divert from the mainstem Willamette. While awaiting resolution of this Opinion, Reclamation has entered into short-term contracts in some of these cases. These requests, if approved as long-term contract obligations, would authorize withdrawal of an additional 25,507 acre-feet of stored water from the mainstem Willamette, beyond the 10,971 acre-feet under current long-term contract. Upon execution of these contracts, the water marketing program would then include 84 active long-term contracts for annual withdrawals of up to 36,478 acre-feet of stored water from the mainstem Willamette River.

Besides those diversions on the mainstem itself, however, flow on the mainstem Willamette is affection by reductions in inflow from contracts that divert water in tributaries below Project dams. Under baseline conditions, a total of 205 long-term Reclamation water service contracts are in effect as a result of the Willamette Project. Cumulatively, these 205 contracts can divert up to a maximum of 50,231 acre-feet of stored water for irrigation, reducing the total flow that enters the Willamette mainstem. There are 62 pending applications that, if approved, would divert an additional 30,200 acre-feet of stored water. Upon execution of these contracts, the Reclamation water contract program will include 267 active long-term contracts for annual irrigation with up to 80,431 acre-feet of stored water; approximately 5% of the active conservation storage space available in project reservoirs.[1]

Under the Proposed Action, Reclamation would cap its water marketing program at 95,000 acre-feet for the term of this Opinion. Taking both existing contracts and pending contract applications into account, 14,569 acre-feet would remain available to meet future irrigation demands under the duration of the Opinion. In the event that future irrigation demand exceeded

[1] The 205 contracts presently in force cover approximately 3% of the available conservation storage space.

the 95,000 acre-feet, Reclamation and the USACE would reevaluate the availability of water from conservation storage for the water marketing program and would consult with the Services prior to marketing additional water.

USACE intends to serve these contracts with water released from storage needed to maintain tributary and mainstem minimum flows. That is, under the Proposed Action more water would be removed from the Willamette River and its tributaries during the irrigation season without any additional water being released from USACE's reservoirs. In general, Reclamation water contracts are supplemental to natural flow water rights held by individual water users and are only exercised when natural flows are insufficient to serve all users and meet instream water rights held by OWRD. Assuming that such conditions would occur for only about 60 days each summer, the total level of future Reclamation-supported water service could reduce flows in some sections of the Willamette River by about 798 cfs, an increase of 376 cfs over existing baseline Reclamation service. Because USACE attempts to maintain flows of 6,000 to 7,000 cfs at Salem during the late summer, this level of Reclamation-supported water use would reduce late summer flows by 13 percent or less.[2] This is a 'worst-case' projection and project-related flow reductions would likely be much less.

Such flow reductions may slightly reduce the habitat area available to rearing juvenile salmon and steelhead during the late summer. Reducing the flow in the river would reduce the mass of water subject to atmospheric heating, causing water temperatures to increase slightly, which might also adversely affect rearing salmonids. This small level of project-induced water development is unlikely to substantially affect the survival of UWR Chinook and UWR steelhead in the mainstem Willamette River. However, when combined with non-project water developments (e.g., OWRD has issued natural flow water rights totaling almost 25,000 cfs in the basin), it must be noted that total water use in the basin is beginning to create conflicts between instream needs (e.g., fish habitat, water quality) and out-of-stream water uses (e.g., domestic, municipal, and irrigation). Ongoing regional planning efforts are focusing on this emerging issue.

This effect is expected to continue and worsen throughout the life of the Proposed Action. Although the USACE proposes to continue its efforts to cooperate with other regional entities to resolve water use conflicts, it does not propose any actions to investigate or reduce the effects of project-supported water use on Willamette River winter steelhead or spring Chinook in the mainstem Willamette River.

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[2] By assuming a short period of water use, and by assuming that all contracted water would be diverted and completely consumed when the river is at its lowest regulated levels, this brief analysis somewhat exaggerates the likely outcome of Reclamation water marketing in the Willamette basin. Under the Proposed Action, USACE would operate the projects to maintain at least 6,000 cfs in the Willamette River at Salem, Oregon, regardless of the level of actual water use.

5.10.2.5 Flow-Related Research, Monitoring & Evaluation (RM&E)

In the mainstem Willamette River and its major tributaries affected by USACE dams, the Action Agencies would conduct studies to characterize functional relationships between anadromous fish habitats and migrations and flows. These studies will focus on multiple aspects of fish distribution (e.g., habitat use) and behavior (e.g., migration timing) in relation to rates of discharge by time of year. The Action Agencies, in cooperation with the Services and the FM Committee, would use this information to better inform and balance tributary and mainstem flow management. Based on the new information, the Action Agencies would, with the agreement of the Services, modify the mainstem flow objectives presented in Table 5.10-2.

This RM&E measure is integral to an ongoing adaptive management program. NMFS strongly supports this type of adaptive management as it improves the likelihood of achieving the ESA's goals of ensuring long-term survival and protection of critical habitat for listed species.

Conclusions

Flow patterns in the mainstem Willamette River have been substantially altered by operations at the USACE's Willamette Project dams and reservoirs. These operations have altered flow regimes in ways that address water pollution, flood control, water supply, and other societal concerns, but have had both positive and negative effects on ESA-listed populations of UWR Chinook and UWR steelhead. All populations of both UWR Chinook and UWR steelhead migrate through the mainstem Willamette River and are known to rear in the river at times. The combined effects of reduced winter peak flows and channel revetments reduce the PCEs of freshwater rearing and migration corridors. A flow-related RM&E program included as part of the Proposed Action will help guide flow management that is favorable for ESA-listed salmonids, particularly as the potential for conflicts between human and salmon needs for water increase over time.

5.10.3 Water Quality

Under the environmental baseline, water quality does not provide properly functioning habitat for UWR Chinook salmon (section 4.10.3.3). NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as described below.

5.10.3.1 Water Temperatures

The beneficial effect of ongoing mainstem flow augmentation from Willamette Project reservoirs on late summer mainstem temperatures is expected to continue under the Proposed Action. Small, adverse, late summer water temperature effects would be increased by additional water deliveries through Reclamation's water marketing program. Maximum summer water temperatures would probably continue to exceed NMFS' criteria for migrating and rearing Chinook salmon and steelhead.

Insufficient information is available to fully identify Project effects on mainstem Willamette water temperatures. Mainstem water temperatures are a substantial contributor to juvenile UWR steelhead mortality through their influence on disease susceptibility and virulence. By reducing spring flows during reservoir refill operations under baseline conditions, the Project has allowed slight increases in water temperature that likely contributed to disease-caused juvenile migrant mortality in the mainstem Willamette. This adverse effect would be reduced by the provision of maintaining minimum flows in the mainstem (Table 5.10-2) under the Proposed Action.

5.10.3.2 Dissolved Oxygen

Ongoing mainstem flow augmentation from Willamette Project reservoirs would also continue to benefit late summer dissolved oxygen levels. However, water column dissolved oxygen levels would still fluctuate below NMFS' criteria for migrating and rearing Chinook salmon and steelhead. The operation of the Willamette Project dams has increased dissolved oxygen concentrations in the lower mainstem Willamette through increased summer flows, and this beneficial effect is also expected to continue under the Proposed Action. Overall, dissolved oxygen in the mainstem would be improved by the Proposed Action.

5.10.4 Physical Habitat Quality

The key Proposed Actions related to physical habitat quality in the mainstem Willamette River subbasin that would affect UWR Chinook salmon and UWR steelhead, and to a lesser extent, LCR Chinook salmon, LCR coho salmon, and LCR steelhead, are listed below.

- Continued operation of 13 Project dams, blocking sediment and large wood transport from upstream reaches and tributaries into the downstream subbasins and ultimately into the mainstem Willamette River.

- Continued reduction in peak flows as part of flood control operations at the two Project dams, restricting floodplain connectivity and preventing creation of new gravel bars, side channels, and alcoves that provide rearing habitat for anadromous salmonids

- Continued existence and maintenance of 22.68 miles of USACE revetments along the mainstem Willamette River (all above Willamette Falls), preventing channel migration and reducing channel complexity.

- Study of effects of Project dams and revetments on mainstem Willamette River habitat and consider projects to restore habitat if authorized and funding becomes available.

5.10.4.1 Substrate, Sediment Transport, Large Wood & Channel Complexity in the Mainstem Willamette River

Under the environmental baseline, substrate, sediment transport, large wood, and channel complexity are degraded and do not support adequate rearing and holding habitat for UWR Chinook salmon and UWR steelhead throughout the mainstem Willamette River (Section 4.10.4). For LCR Chinook salmon, LCR coho salmon, LCR steelhead, and Clackamas River and Molalla River populations of UWR Chinook salmon and steelhead, which are present in the Willamette River downstream of Willamette Falls, and possibly for the Interior salmonid ESUs/DPSs, which may spend limited periods of time rearing near the mouth of the Willamette River, baseline conditions for these habitat features are also degraded. NMFS expects that conditions would not improve, and could degrade further under the Proposed Action, as shown in Table 5.10-3 (end of this section 5.10) and described below.

Under the Proposed Action, operation of the 13 Project dams for flood control would continue to store sediment and large wood in the reservoirs, trapping sediment and large wood from 27% of the Willamette Basin as measured at Salem. Additionally, Project operation would continue to reduce the magnitude and frequency of flood flows capable of recruitment of large wood and sediment from floodplains and of creating new bars, side channels, and alcoves. Finally, continued existence and maintenance of 22.68 miles of revetments along the mainstem Willamette River above Willamette Falls would prevent river migration and contribution of sediment, further depriving the river of sediment and the ability to create new gravel bars or side channels.

Several undammed tributaries enter the Willamette and transport large wood and gravel into the mainstem Willamette. However, many drain the Coast Range mountains, which do not contain sediment of the same size or quantity as the regulated rivers draining the Cascades. As described in Baseline section 4.10.3.4, additional sediment enters the mainstem Willamette as a result of land use activities such as road building, agriculture, and forestry; however, this sediment is primarily silts and fine particle sediments that increase turbidity and settle over coarser gravel, reducing habitat quality for rearing salmonids and the invertebrates on which they feed. Thus, other sources of sediment would not replace the lack of coarse gravels that are blocked by Project dams.

As a result of these actions, already impaired juvenile rearing and adult holding habitat, primarily in the mainstem Willamette River above Willamette Falls, would continue to degrade, limiting the abundance and productivity of all populations of UWR Chinook salmon and UWR steelhead. This adverse effect would likely cause more harm to the Middle Fork Willamette and McKenzie River UWR Chinook salmon populations than the other populations because these upper basin populations most likely relied on the once-extensive complex rearing habitat in the middle reaches of the mainstem Willamette for juvenile rearing. A lack of complex rearing and high-water refugia habitat in the mainstem Willamette River could limit juvenile production in the basin.

Although continued Project operation would also limit sediment and large wood transport and reduce flood magnitude and frequency into the lower mainstem below Willamette Falls, it would not be likely to significantly alter this reach that is naturally constrained by basaltic trenches. However, reduced flood frequency and magnitude would likely continue to prevent channel forming and overbank flows near the mouth of the Willamette River, where complex habitat once provided refugia for rearing juveniles of all 5 ESUs (UWR Chinook salmon, UWR steelhead, LCR Chinook salmon, LCR coho salmon, LCR steelhead). The magnitude and extent of juvenile rearing near the mouth of the Willamette River by other ESUs (Interior and other LCR species) is unknown, but it is likely that a small portion of juveniles rear in this habitat. Project operation would thus be expected to reduce available rearing habitat in this area due to reduced flood flows, resulting in channel simplification and fewer side channels and alcoves.

Conclusion

The Proposed Action would result in continued degradation of complex habitat in the mainstem Willamette River above Willamette Falls, likely reducing the carrying capacity of this habitat for rearing juvenile fish, thereby reducing the number of UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Although less severe, the Proposed Action would likely reduce channel forming flows needed to maintain and create complex habitat in the lower Willamette River near its mouth. This reduced channel complexity would reduce available habitat for rearing juveniles of UWR and LCR ESUs, and potentially Interior and other LCR populations that may rear in this reach during part of their outmigration. Aside from unspecified habitat restoration actions that may result from gravel, large wood, and habitat restoration studies, the Action Agencies do not propose any measures that would restore large wood, sediment transport, and channel complexity in the mainstem Willamette River.

5.10.4.2 Riparian Vegetation & Floodplain Connectivity in the Mainstem Willamette River

Under the environmental baseline, riparian vegetation and floodplain connectivity are degraded and do not support adequate rearing, holding, and spawning habitat for UWR Chinook salmon and UWR steelhead (Section 4.10.3.4). For LCR Chinook salmon, LCR coho salmon, and LCR steelhead, and the Clackamas UWR Chinook salmon and steelhead populations, species present in the Willamette River downstream of Willamette Falls, baseline conditions for these habitat features are also degraded. NMFS expects that conditions would not improve, and could degrade further, under the Proposed Action, as shown in Table 5.10-3 and described below.

Under the Proposed Action, operation of the Project dams for flood control, and continued existence and maintenance of 22.68 miles of USACE revetments along the mainstem Willamette River above Willamette Falls (and none below) would continue to degrade riparian vegetation and floodplain connectivity by preventing recruitment of large wood and sediment that create new bars and islands on which riparian vegetation can establish and by preventing peak flows that maintain stream connectivity to the floodplain. Although the Proposed Action includes study of potential Project flow releases to simulate peak flows, as well as habitat restoration studies, there is no certainty that project outflows would be modified or habitat restoration work would be done during the term of this Opinion.

The extent and function of the mainstem Willamette River's riparian vegetation and floodplains have been and would continue to be impaired by operation of the Willamette Project under the Proposed Action. As described in section 4.10.6, USACE Willamette Project revetments replaced about 46 miles of riparian vegetation along the mainstem Willamette River. Under the Proposed Action, the USACE retains maintenance responsibility for 22.68 miles of these revetments. These operations would continue to deprive downstream reaches of sediment, channel-forming flows, and large wood needed to create gravel bars, islands, and floodplains on which new riparian vegetation can establish. Reduced inundation of forested floodplains reduces nutrient and organic matter exchange during flood events and reduces the availability of high-water refugia for juveniles, which could limit over-wintering survival of rearing juveniles.

Because Project dams restrict fish access to upper tributary reaches, alter temperature regimes, and interrupt sediment and large wood from maintaining complex habitat in the lower reaches of the Middle Fork Willamette, McKenzie, North and South Santiam rivers, there is less juvenile rearing habitat in these tributaries for UWR Chinook salmon and UWR steelhead. This increases the important role of mainstem rearing for juvenile abundance and productivity and places even more emphasis on the need to maintain hydrologic processes that protect and restore rearing habitat in the mainstem Willamette River.

These adverse effects would likely cause more harm to listed anadromous fish in the Middle Fork Willamette, McKenzie, Calapooia, and North and South Santiam populations of UWR Chinook salmon and the North and South Santiam and Calapooia populations of UWR steelhead than the other populations because flood flows in the mainstem Willamette above Willamette Falls historically provided more opportunity for floodplain connectivity than in the bedrock-constrained reach below the Falls. Molalla and Clackamas UWR Chinook populations, and Molalla, Westside tributary and Clackamas UWR steelhead populations, as well as individuals of LCR Chinook salmon, coho salmon, and steelhead populations in the lower Willamette River, and potentially Interior ESUs that may rear at the mouth of the Willamette River during part of their outmigration, would be adversely affected to a lesser degree as a result of less frequent flooding in this lower river reach.

Conclusion

The Proposed Action would continue to reduce the extent, quality, and inundation frequency of riparian and floodplain forests in the mainstem Willamette River above Willamette Falls. The reduced extent of riparian vegetation (combined with reduced peak flows and limited channel migration) hinders recruitment of large wood into the aquatic system, which is needed to deposit spawning gravel, create resting pools for migrating adults, and provide cover for rearing juveniles or outmigrating smolts. Infrequent inundation of forested floodplains due to flood control operations would reduce nutrient and organic matter exchange during flood events, and reduce the availability of complex high-water refugia for juveniles, which could limit survival of rearing juveniles. These adverse effects would likely reduce the carrying capacity of habitat for rearing juvenile fish, thereby reducing the number of individual UWR Chinook salmon and UWR steelhead that can be produced in this presently degraded habitat. Although less severe, the Proposed Action would likely reduce floodplain connectivity and riparian forest creation and maintenance in the lower Willamette River near its mouth. This would reduce available habitat for rearing juveniles of UWR and Clackamas River populations of LCR ESUs, and potentially individuals of Interior and other LCR populations that may rear in this reach. For the populations of Interior and other LCR ESUs, because the duration of individual exposure is low and the percentage of the populations that might rear in this affected habitat is likely very low, NMFS does not expect the effects of the Proposed Action to reduce abundance and productivity of these other populations. Aside from unspecified habitat restoration projects and potential Project peak flow releases that may be recommended by the Willamette Floodplain Restoration Study or other habitat restoration studies described in the Supplemental BA, Section 3.5.2, Offsite Habitat Restoration Actions (USACE 2007a), the Action Agencies do not propose any measures that would restore riparian vegetation and floodplain connectivity in the mainstem Willamette River.

5.10.5 Hatcheries

There are no hatchery facilities or hatchery fish releases in the mainstem Willamette River. Therefore, the specific effects of the hatchery facilities are evaluated in the specific subbasin where the hatchery is located. The effects of hatchery programs on broodstock collection, genetic introgression, masking, and nutrient cycling are evaluated also in each specific population area.

All hatchery spring Chinook and summer steelhead are released as smolts. The intent is for these hatchery fish to actively emigrate to the ocean, thus minimizing the period of time hatchery fish are potentially interacting with naturally rearing listed fish downstream of the hatcheries. The primary effects of the hatchery programs in the mainstem that needs to be assessed are the interaction between hatchery fish and natural-origin fish as they emigrate through the mainstem Willamette on their way to the ocean and 2) the interaction between hatchery and natural-origin fish upon their return as adults in the mainstem Willamette River. The following discusses these effects.

5.10.5.1 Disease

Hatchery fish can be agents for the spread of disease to wild fish. Due to the high rearing densities of fish in the hatchery, hatchery fish can have elevated levels of certain pathogens, disease, and/or bacteria. After they are released, these fish may expose and/or transfer the disease to wild fish. Below is an assessment of these risks to the juvenile and adult life stages.

Juveniles
In the mainstem Willamette River, the risk of hatchery fish spreading disease to wild juvenile Chinook salmon and winter steelhead is unknown. Hatchery fish are released as smolts from the hatchery facilities in the tributaries and are supposed to actively emigrate to the ocean. Available data suggests that smolt emigrations from any Willamette Basin hatchery to the lower Columbia River probably occur in less than a week (Friesen et al. 2007; Schreck et al. 1994). Therefore even though significant juvenile fish rearing does occur in the mainstem Willamette River (Schroeder et al. 2006), the likely exposure time between actively-migrating hatchery fish and naturally-rearing fish is likely to be minimal.

Adults
The potential also exists for returning hatchery fish to spread diseases to wild adult fish commingled in the mainstem Willamette River. The risk of hatchery fish spreading diseases in the Willamette River may be substantial since hatchery Chinook outnumber natural fish 10 to one. There is likely no effect of hatchery adults on winter steelhead due to the differences in run timing.

5.10.5.2 Competition/Density-Dependence

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Information on the potential competitive interactions between hatchery and wild fish is very limited in the Willamette Basin. Below is an assessment of the likely implications on the juvenile and adult life stages.

Juveniles
Since all hatchery fish are released as smolts and are expected to emigrate quickly to the ocean, it is unlikely significant competitive interactions will occur. In the mainstem Willamette, the habitat used by naturally rearing fish is primarily along the shorelines (Schroeder et al. 2006). For actively migrating hatchery smolts, they are traveling in the thalweg of the main river, thus using different habitats.

Adults
Given the problem of prespawning mortality in the Willamette Basin, it is possible that large numbers of returning hatchery adults could be causing an adverse effect on natural-origin fish. However, in the mainstem Willamette, this is unlikely because the fish are actively migrating upstream and there are no barriers to migration until the fish move into the tributaries. Without physical barriers, there is less chance that fish will be concentrated in one spot in the mainstem Willamette, reducing the chance that diseases could be spread laterally from hatchery to natural-origin fish. Therefore, adverse effects of competition and density-dependence factors of hatchery fish on natural-origin adults in the mainstem Willamette are likely to be small but unquantifiable.

5.10.5.3 Predation

Hatchery fish migrating through the mainstem Willamette probably eat some co-occurring natural-origin fish. In general, salmonids can prey upon fish approximately 2/3 of their size. Thus there is significant potential for hatchery summer and spring Chinook to prey upon wild steelhead and Chinook. Even though information is lacking on the extent of this issue, predation by hatchery fish undoubtedly occurs. Schroeder et al. (2006) examined predation by hatchery summer steelhead and rainbow trout on Chinook fry in the McKenzie River. Predation did occur on Chinook fry by a few fish. However, due to the fast digestion rates of Chinook fry in the stomachs of summer steelhead and rainbow trout (e.g., one to seven hours), it was difficult to estimate the amount of predation in their sampling design. Given the primary and secondary limiting factors identified for Willamette populations, predation by hatchery fish is not likely a limiting factor and the risk to listed fish is low.

Juvenile summer steelhead that are the progeny of naturally spawning summer steelhead in winter steelhead habitat could also predate upon listed age-0 and age-1 juvenile winter steelhead. The extent of this potential problem is unknown at this time. However, monitoring and evaluation is scheduled to occur to evaluate the proportion of juvenile steelhead that are progeny of summer steelhead.

5.10.5.4 Residualism

All hatchery programs in the Willamette Basin release hatchery fish as smolts. The intent is to release the hatchery fish at a size and time so that they will actively emigrate to the ocean; thus minimizing the potential interaction between hatchery and wild fish. However, a percentage of the smolts do not emigrate and residualize in the river. These residual fish may emigrate to the ocean at a later time or may stay in freshwater the rest of their life.

In general, hatchery steelhead have more of a tendency to residualize than hatchery spring Chinook. In the Willamette Basin, the primary concern is with residual summer steelhead. The percentage of the smolt release of summer steelhead that do residualize is unknown. However, residual summer steelhead have been observed in all areas where hatchery fish are released. Several new actions are included in the Proposed Action that would help reduce the adverse effects of residual summer steelhead on wild winter steelhead and spring Chinook. The most beneficial is the proposal to not release any summer steelhead smolts that do not volitionally emigrate from the hatchery facility. These "non-migrants" would be collected and released into standing water bodies for trout fisheries. Previously, all of these non-migrant fish were forced out into the river. In addition, ODFW is proposing a new angling regulation that will allow the harvest of any fin-clipped, residual summer steelhead in all recreational fisheries. These changes in hatchery management and ODFW angling regulations will decrease the number of residual hatchery fish left in the river and thus reduce adverse effects of residual fish.

5.10.6 Fisheries

As discussed in the "General effects of hatchery programs on ESA-listed salmon and steelhead" section above, the production of hatchery fish can lead to commercial and recreational fisheries that cause the overharvest of natural-origin fish. An abundance of hatchery fish can promote expanding fisheries, which may be detrimental to commingled natural-origin fish. In the Willamette, all hatchery fish have been mass marked since the 1990s. This mass marking has facilitated implementation of selective fisheries—where only hatchery fish can be harvested. Thus freshwater fishery impacts on winter steelhead and spring Chinook have been reduced substantially compared to historic harvest rates. Freshwater fishery impacts are now in the range of 1-5% for winter steelhead and 8-12% for spring Chinook populations in the Willamette Basin.

The production of Willamette hatchery fish are of no consequence to the management of ocean fisheries. In general, steelhead of natural- or hatchery-origin are rarely caught in ocean fisheries. Hatchery spring Chinook are caught in ocean fisheries, particularly in Alaska and West Coast Vancouver Island fisheries (see Figure 4.2-13). However, these hatchery fish are not a driver for fisheries management. Protection of other stocks of concern in Canada and the United States currently constrain ocean fishery quotas and regulations. In addition, harvest of Willamette spring Chinook in ocean fisheries is governed by the Pacific Salmon Treaty between the US and Canada and impacts have been typically been in the range of 10-15%.

5.10.7 Summary of Effects on Population Traits

Below is a summary of the effects of the Proposed Action in the mainstem Willamette on the four Viable Salmonid Population (VSP) parameters (abundance, productivity, spatial structure, and diversity) for all of the listed fish populations and ESUs that use the mainstem Willamette River for portions of their life cycles. These VSP parameters are described in detail in the Rangewide Status Chapter (section 3). Each subbasin section of the Effects Chapter (sections 5.2 through 5.9) summarizes effects of the Proposed Action for each population. This summary considers only the effects that occur in the mainstem Willamette that, together with effects of the Proposed Action in the subbasin, determine effects on each population and ultimately at the ESU level. Table 5.10-3 also summarizes the VSP effects.

5.10.7.1 Abundance

The majority of the natural-origin populations of UWR Chinook salmon have very low current abundances (less than a few hundred fish in each of the Molalla, North Santiam, South Santiam, Calapooia, and Middle Fork Willamette), with only the Clackamas and McKenzie populations exceeding 1000 spawners and possibly showing an increasing trend in abundance (Section 3.2.1.3). UWR steelhead abundance in the four populations (Molalla, North Santiam, South Santiam, Calapooia) is moderate, though depressed from historical levels (Section 3.2.2.3).

Minimum flows and their effects on water quality in the mainstem Willamette would result in some increased abundance of UWR Chinook salmon and UWR steelhead. However, the Proposed Action would also cause decreased abundance of these ESUs associated with lost fry and juvenile rearing habitat in the mainstem Willamette due to ongoing maintenance of revetments and lack of channel-forming peak flows. Abundance would be most unfavorably affected for UWR Chinook salmon and UWR steelhead populations that would use off-channel rearing habitat and complex habitat above Willamette Falls.

5.10.7.2 Productivity

The Proposed Action would have both beneficial and negative effects on productivity of populations of UWR Chinook salmon and UWR steelhead in the mainstem Willamette. Minimum flows and their effects on water quality would support productivity, while continued degradation and loss of juvenile rearing habitat caused by revetment maintenance and reduction in channel-forming and over-bank flows would reduce productivity. These negative effects would be greatest for the populations spawning above Willamette Falls, namely steelhead from the Molalla, North Santiam, South Santiam, and Calapooia, and Chinook salmon from those subbasins plus the McKenzie and Middle Fork Willamette. Without substantial improvements in rearing habitat conditions in the mainstem Willamette, and in the near term, before passage is provided to suitable rearing habitat above Project dams, NMFS expects the productivity of these populations to remain at low levels or continue to decrease. Habitat enhancements in the mainstem that provide complex juvenile rearing habitat and off-channel refugia are needed in the near term to prevent further decline in productivity. The Proposed Action lacks certainty that such improvements would be carried out during the term of this Opinion.

5.10.7.3 Spatial Structure

In the mainstem Willamette, the Proposed Action does not affect spatial structure of any of the listed ESUs, except to the extent that it restricts access to off-channel refugia and rearing habitats.

5.10.7.4 Diversity

Population traits for all of the ESUs considered in this Opinion are now not as diverse as they were in historic populations, and this decreases the ability of salmon and steelhead to respond and survive in response to fluctuating environmental conditions. NMFS expects the Proposed Action to continue to degrade habitat, and limit fry and juvenile rearing habitat in the mainstem Willamette, especially in reaches above Willamette Falls. This reduction in mainstem rearing habitat reduces diversity by selecting for life history types that either spend most of its freshwater rearing in tributaries or that quickly migrate downstream to rear in the estuary. By reducing the diversity of life history types, populations are more at risk because catastrophic events in the remaining habitat can destroy a larger proportion of the population and without segments of the population using different life history strategies (such as mainstem rearing), the population's resiliency to these events is low.

The effects of hatchery fish production on diversity are described in the specific subbasin sections where hatchery facilities are located (Sections 5.2 Middle Fork Willamette, 5.3 McKenzie, 5.5 South Santiam, and 5.6 North Santiam).

Conclusion for UWR steelhead from the Molalla, North Santiam, South Santiam, and Calapooia, and UWR Chinook salmon from those subbasins plus the McKenzie and Middle Fork Willamette:

For these UWR Chinook salmon and steelhead populations that migrate through and rear in the mainstem Willamette from above Willamette Falls, the Proposed Action would have both positive (related to increased summer flows, improving water quality) and negative (related to reduced rearing habitat associated with revetment maintenance and lack of peak channel-forming flows) effects. In the near term under the Proposed Action, passage at Project dams in the Middle Fork Willamette, McKenzie, South Santiam, and North Santiam would remain inadequate to address spatial structure and the need to access upstream habitat to realize increases in abundance and productivity. To prevent further declines in these populations in the near term, efforts are needed to improve and restore mainstem Willamette rearing habitat. However, under the Proposed Action, NMFS expects that continued maintenance of revetments and reduction in peak flows would lead to further decline in abundance and productivity due to loss of rearing habitat.

Conclusion for UWR Chinook salmon from the Clackamas, as well as populations of LCR Chinook salmon, LCR coho salmon, and LCR steelhead and Interior ESUs/DPS that may use the lower Willamette River below Willamette Falls:

The Proposed Action would not be likely to have a measurable effect on these populations and additional ESUs/DPSs that may use the lower Willamette mainstem for juvenile rearing and migration. The USACE has identified no revetments in this lower reach that are maintained by the Action Agencies. Although the Project's reduced flood flows would likely limit channel forming processes near the confluence of the Willamette and Columbia rivers, this effect would be small and overshadowed by ongoing landuse development activities and Columbia River operations.

5.10.8 Effects of the Proposed Action on Designated Critical Habitat

The mainstem Willamette River from its mouth to its origin at the confluence of the Middle Fork and Coast Fork at RM 187 has been designated as critical rearing/migration habitat for UWR Chinook salmon and UWR steelhead. Table 5.10-3 shows the anticipated effects of the Proposed Action on VSP parameters for UWR Chinook salmon and UWR steelhead and on the PCEs of Critical Habitat for these species.

The Proposed Action would have both positive and negative effects on critical habitat in the mainstem Willamette River. Proposed minimum flows for the mainstem Willamette would continue to benefit rearing and migration habitat by providing improved summer water quality (lower water temperatures, higher dissolved oxygen, and lower concentrations of pollutants) than under the baseline without the Project-controlled flows. The minimum flows would also continue (relative to the recent past) to aid in downstream migration of juvenile salmonids during spring, particularly UWR Chinook salmon and UWR steelhead from the Middle Fork Willamette, McKenzie, North Santiam, and South Santiam populations, all of which migrate from upper basin tributaries. Upstream migration of adult Chinook salmon from these same populations is also benefitted by the minimum flows' effect of reducing thermal blockages. However, continued existence and maintenance of 22.68 miles of revetments and reduced flood flows would continue to harm rearing habitat by preventing channel-forming events that create and maintain complex rearing habitat and overbank flows that allow access to off-channel rearing habitats. This continued loss in rearing habitat is most damaging to critical habitat in the mainstem Willamette River above Willamette Falls, designated for UWR Chinook salmon and UWR steelhead. For that critical habitat designated for LCR Chinook salmon, Coho salmon and steelhead, the Proposed Action's reduced flood flows would likely have little effect on rearing and migration habitat in the lower Willamette, including once-complex habitat near the confluence of the Willamette and Columbia rivers.

Table 5.10-3 PCE Effects of PA on populations (VSP column) and Critical Habitat (PCE column) in the Mainstem Willamette River subbasin. Modified from USACE 2007a, Table 6-7.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater migration corridors	Habitat access	Physical barriers	The proposed action does not cause any physical barriers to migrations within the mainstem Willamette River.	None
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quantity (flow/hydrology)	Change in peak/base flow, revetment maintenance	By interrupting sediment transport from the tributary source areas into the mainstem corridor, the proposed action would slightly reduce the availability of spawning substrates within the mainstem Willamette River. Through the continued existence and maintenance of revetments and the control of peak flows, the proposed action would reduce channel complexity, continuing the already reduced juvenile rearing habitats in the mainstem. By reducing spring flows during reservoir refill, the proposed action would contribute slightly to juvenile UWR steelhead migrant mortality. This effect is minimized by the proposed action's commitment to maintain streamflow levels known to minimize these adverse effects.	Reduces spawning habitat. Mainstem spawning is minor to inconsequential. Reduce freshwater rearing habitat. Mainstem rearing habitat may be seasonally important. Reduce suitability of migratory corridor.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Temperature	May affect the seasonal use of mainstem Willamette by rearing salmon and steelhead. By reducing spring flows during reservoir refill, the proposed action would slightly increase temperature, making juvenile UWR steelhead migrant more susceptible to disease, and more likely to die. This effect is minimized by the proposed action's commitment to maintain minimum flow levels that will reduce the adverse effects of reservoir refill on mainstem Willamette water temperature.	During spring flows, reservoir refill would continue to reduce mainstem flows, resulting in small increased temperature that adversely affects rearing and migration habitat. Minimum flows would partially offset this adverse effect. During summer months, the Proposed Action slightly reduces temperature compared to baseline conditions, resulting in improved rearing and migration habitat.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total suspended solids/turbidity	The reduction in turbidity may reduce juvenile survival by making them more susceptible to predation.	By reducing peak flows, capturing most incoming bedload sediments, and reducing downstream settleable solids concentrations, the tributary projects likely reduce mainstem turbidity and sediment transport. Sediment transport is discussed in Water Quantity above.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Chemical contamination/nutrients	No effect	No effect

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Dissolved oxygen (DO)	Proposed Action slightly offsets other human-caused actions that decrease DO, to avoid incremental loss of abundance and productivity of UWR Chinook salmon and steelhead and LCR Chinook salmon, coho salmon, and steelhead.	Continued improvement of DO in lower Willamette resulting from higher summer flows
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Water quality	Total dissolved gas (TDG)	No effect	No effect
Freshwater spawning sites	Habitat elements	Substrate	Continued lack of new gravels to existing habitat in the mainstem Willamette above Willamette Falls would reduce abundance and productivity of UWR Chinook salmon and UWR steelhead by limiting and degrading available juvenile rearing habitat. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams would continue to block sediment transport from 27% of the Willamette basin, reducing gravel bar creation in the mainstem Willamette, and thereby limiting stream functions that create complex habitat for rearing juveniles.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large woody debris (LWD)	Continued lack of large wood reduces abundance and productivity of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls because holding and rearing habitat would continue to degrade and would not be replaced. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams would continue to block transport of large wood from 27% of the Willamette basin and 22.68 miles of revetments would continue to prevent floodplain connectivity, reducing large wood recruitment from streambanks, resulting in less structure available to create complex channel habitat, gravel bars and large pools.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool frequency and quality	Continued degradation of pool habitat would reduce juvenile rearing and adult holding habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Operation of Project dams and continued existence and maintenance of revetments would continue to prevent peak flows and block sediments and large wood, preventing channel movement that would allow for new pools to form.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Continued lack of off-channel habitat would reduce rearing habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Continued reduced off-channel habitat in the mainstem Willamette, primarily in the reach above Willamette Falls as well as near the mouth. Project operation would continue to reduce peak flows, limiting overbank flows and channel forming processes. Although studies may consider special operations to provide peak flows, the Action Agencies provide no certainty that this operation would occur during the term of this Opinion, nor that the operation would open up off-channel habitat.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater spawning sites Freshwater rearing	Channel conditions and dynamics	Width/depth ratio	Continued degraded channel conditions would reduce rearing habitat, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation would continue to reduce peak flows and block large wood and sediment transport, limiting pool formation. Although studies may consider special operations to provide peak flows and funding habitat restoration projects, the Action Agencies provide no certainty that these measures would occur during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	Degraded streambanks would inhibit channel forming processes that create complex habitat for juvenile rearing and adult holding, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent streambanks from supporting natural floodplain function in the mainstem Willamette River. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve streambank conditions, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Continued lack of floodplain connectivity reduces availability of off-channel habitat, limiting available rearing habitat, including reduced macroinvertebrate production as a food supply, resulting in lowered productivity and abundance of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above Willamette Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent overbank flow and side channel connectivity in the mainstem Willamette River, especially in the reach above Willamette Falls and in the reach near the mouth. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially improve off-channel habitat, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.
Freshwater spawning sites Freshwater rearing Freshwater migration corridors	Watershed conditions	Riparian reserves	Continued degradation of riparian habitat would reduce large wood available for channel complexity, thereby reducing already limited rearing and holding habitat, resulting in lowered abundance and productivity of UWR Chinook salmon and UWR steelhead in the mainstem Willamette above the Falls. LCR Chinook salmon, coho, and steelhead and Interior species would be affected to a lesser degree due to continued loss of habitat near the mouth of the Willamette River.	Project operation and continued operation and maintenance of revetments would continue to prevent formation of new gravel bars on which riparian vegetation could grow in the mainstem Willamette River above the Falls and near the mouth. Although studies may consider special operations to provide peak flows, and habitat enhancement projects may potentially restore riparian vegetation, the Action Agencies provide no certainty that these changes would be funded or carried out during the term of this Opinion.

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Section 5.11
Lower Columbia River, Estuary & Coastal Ocean Effects

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5.11 LOWER COLUMBIA RIVER, ESTUARY & COASTAL OCEAN

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

- All populations of Columbia basin salmon and steelhead use the lower Columbia River, estuary, and plume as a migration corridor and some species use the lower river and estuary for rearing. The Proposed Action would:
  - Affect flows in the lower Columbia River, with very small decreases during spring and small increases during fall and winter.
  - Reduce inputs of large wood and sediments/turbidity from the Willamette River.
- The Proposed Action is likely to have very small (unmeasurable) negative effects on juvenile migration and rearing habitats, the abundance or productivity of the listed species, and the PCEs water quantity, safe passage, floodplain connectivity, and cover.

This section considers the effects of the Proposed Action on listed fish and fish habitat characteristics in the lower Columbia River and estuary, from the confluence of the Willamette River near Portland, Oregon, (Columbia RM 100) to the mouth, and in coastal areas occupied by Southern Resident killer whales influenced by Willamette Project operations (i.e., within the Columbia River plume). All of the salmonid populations and ESUs/DPSs considered in this Opinion use these reaches to varying extents for parts of their life cycles.

The Proposed Action includes the following actions that would be likely to affect listed salmonid populations using the lower Columbia mainstem for juvenile rearing and juvenile and adult migration:[1]

- Project dams: continued operation and maintenance under existing configuration of 13 Project dams in major tributaries of the Willamette River including seasonal drafting and refilling operations.
- Water contract program: continued issuance of contracts by Reclamation for withdrawal of water released from storage for irrigation use.
- Hatchery Mitigation: large numbers of hatchery-produced anadromous salmonids, including spring Chinook and summer steelhead from the Willamette Hatchery program, pass through the lower Columbia River and estuary as juveniles and adults.

In this section, NMFS considers the effects of the Proposed Action on all populations of listed salmon and steelhead using the lower Columbia River, estuary, and plume.[2] In general, Project flow management operations and water contracting would continue to have small effects on

[1] Habitat requirements and adult use of the estuary are unknown (Fresh et al. 2005).
[2] NMFS has determined that the Proposed Action and the RPA are not likely to adversely affect the Southern Resident killer whale or the Southern DPS of green sturgeon (Section 1.1; Consultation History and Appendices A and B).

flows in the lower Columbia River, estuary, and plume, but would not affect conditions elsewhere in the coastal ocean.

5.11.1 Water Quantity/Hydrograph

The Proposed Action would continue to reduce average monthly Columbia River flows below the Willamette confluence from February through May by a range of less than 1% to 3% (Table 4.11-3), These very small reductions are likely to have a slight to negligible negative effect in terms of increased travel time and thus susceptibility to predators for spring migrating juvenile UWR Chinook, UWR steelhead, LCR coho, CR chum, UCR spring Chinook, SR spring/summer Chinook, SR sockeye salmon, LCR steelhead, MCR steelhead, UCR steelhead, and SR steelhead. Under the environmental baseline, the Action Agencies will relocate Caspian terns from East Sand Island to sites outside the estuary by 2010, and are continuing efforts to control predation by Northern pikeminnows (NMFS 2008a). Both of these actions will reduce the risk of predation in this portion of the action area.

From June through January, the Proposed Action would increase average monthly flows in the lower Columbia River by a range of less than 1% to 4.5% (Table 4-11-3). These flow increases are small, but could be relatively substantial during low flow years. The effect would be a slight to negligible decrease in travel time (corresponding to a slight to negligible increase in survival) for juvenile salmonids that migrate through the lower Columbia River during summer (LCR fall Chinook, SR fall Chinook, and subyearling emigrants from the UWR Chinook ESU), or use the lower river and estuary to rear (LCR fall Chinook and CR chum and subyearling UWR Chinook).

5.11.2 Physical Habitat

By reducing peak spring flows in the Willamette River, the Proposed Action would have a very small negative effect on the frequency of channel-forming and over-bank flows that create off-channel habitat and maintain floodplain connectivity in the lower Columbia River. The Proposed Action is also expected to have a very small negative effect on inputs of large woody debris and sediment/turbidity, trapped in Project reservoirs, to the mainstem lower Columbia. Effects on salmonids and their habitat are likely to be slight to negligible (Section 5.11.1). In addition, the Action Agencies are providing funding to implement a 10-year estuary habitat restoration program that addresses limiting factors as part of the RPA for FCRPS hydrosystem operations (NMFS 2008a). This program, which is part of the environmental baseline for this consultation, will further reduce any slight to negligible effects of the proposed action on habitat in the lower Columbia River and estuary.

5.11.3 Hatchery Mitigation Program

General effects of hatchery programs on species viability are discussed in Section 4.11.2 and in Appendix C to NMFS (2008b). Large numbers of hatchery produced salmon and steelhead including spring Chinook and summer steelhead from the Willamette hatchery mitigation program pass through the estuary as both juveniles and adults. There is evidence of density-dependent effects on salmon and steelhead growth and survival, but whether the underlying factor or factors include competition with hatchery-origin fish remains poorly understood. Nickelson (2003) suggested an alternate mechanism, that predators are attracted to large aggregations of hatchery fish making natural-origin fish in the same area are more susceptible to piscivorous fish, birds, and mammals. However, evidence for these effects is inferential at this time.

5.11.4 Summary of Effects on Salmonids

Effects of Willamette Project operations on flow in this part of the action area are likely to be very small and effects on habitat features and thus on the abundance, productivity, spatial structure, or diversity of any of the 13 species of salmonids considered in this consultation are likely to be slight to negligible. For species with subyearling juvenile emigrants (juvenile LCR fall Chinook and CR chum and subyearlings from the UWR Chinook ESU), the Proposed Action is not expected to affect floodplain connectivity, channel complexity, or the availability of shallow, low velocity rearing habitat (Table 5.11-1). The Proposed Action is therefore not expected to have a measurable effect on population abundance, productivity, and spatial structure of species that only interact with the Action in this part of the action area (i.e., do not spawn and rear in the Willamette Basin). In addition, relocating terns from the estuary, and the habitat restoration projects described in Section 4.11.4, are expected to improve juvenile survival compared to conditions in recent years. The Proposed Action is not expected to affect habitat conditions for salmonids in the coastal ocean (including the Columbia River plume).

5.11.5 Effects of the Proposed Action on Designated Critical Habitat

Due to its importance as a migratory corridor, the lower Columbia River from the Willamette River confluence to the mouth has been designated as critical habitat (migration corridor) for 12 species of salmon and steelhead in the Columbia basin. As described above, the Proposed Action is expected to have slight to negligible effects on the functioning of habitat elements that correspond to PCEs of critical habitat (water quantity, safe passage, floodplain connectivity, and natural cover) in this portion of the action area (Table 5.11-1).

Table 5.11-1. Effects of Willamette Project Proposed Action on ESA-listed salmon and steelhead populations (VSP column) and the primary constituent elements of critical habitat (PCE column) in the lower Columbia River, estuary, and plume/coastal ocean. Modified from Table 6-7 in USACE 2007a.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Water quantity (flow/hydrology)	Change in peak/base flow, revetment maintenance	Very small reductions in spring flows (February-May) during reservoir refill with slight to negligible effects on abundance or productivity. Very small reductions in channel complexity in the lower Columbia River and estuary during spring with slight to negligible effects on abundance or productivity.	Very small reductions in water quantity and safe passage in the migration corridor during spring. Slight to negligible reductions in water quantity, floodplain connectivity, and natural cover in freshwater/estuarine rearing areas.
Freshwater rearing Freshwater migration corridors	Water quality	Turbidity	Slight to negligible reduction in turbidity corresponds to a slight to negligible reduction in juvenile survival (i.e., susceptibility to predation) and thus on abundance or productivity.	Slight to negligible reduction in safe passage.
Freshwater rearing Freshwater migration corridors	Water quality	Chemical contamination/ nutrients	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Water quality	Dissolved oxygen (DO)	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Water quality	Total dissolved gas (TDG)	No effect.	No effect.
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Large woody debris (LWD)	Slight to negligible reduction in the delivery of LWD to the lower Columbia River and estuary with slight to negligible effects on the abundance or productivity of ocean-type Chinook ESUs rearing in this part of the action area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible negative effect on cover in juvenile rearing areas.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing sites Freshwater migration corridors	Habitat elements	Pool frequency and quality	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Habitat elements	Off-channel habitat	Slight to negligible effect on the development and maintenance of off-channel habitat in the lower Columbia River and estuary with slight to negligible effects on the abundance and productivity of ocean-type Chinook ESUs rearing in the area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible effect on cover in juvenile rearing areas.
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Width/depth ratio	No effect.	No effect.

Habitat Needs	Pathway	Indicator	Effects on VSP Parameters	Effects on PCEs
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Streambank condition	No effect.	No effect.
Freshwater rearing Freshwater migration corridors	Channel conditions and dynamics	Floodplain connectivity	Slight to negligible effect on the development and maintenance of floodplain connectivity in the lower Columbia River and estuary with slight to negligible effects on the abundance or productivity of ocean-type Chinook ESUs rearing in this portion of the action area (juvenile LCR fall Chinook and CR chum and subyearling emigrants from the UWR Chinook ESU).	Slight to negligible effect on floodplain connectivity in juvenile rearing areas.

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Chapter 6
Cumulative Effects

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6 CUMULATIVE EFFECTS

As part of the Court-ordered collaboration process for the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2008a), the State of Oregon provided information on various ongoing and future or expected projects that NMFS has determined are reasonably certain to occur and will affect recovery efforts in the Willamette and lower Columbia basins (see Table 17-5 in Chapter 17 in USACE 2007b [FCRPS Comprehensive analysis]). All of these actions are either completed or ongoing and are thus part of the environmental baseline, or are reasonably certain to occur.[1] They address protection and/or restoration of existing or degraded fish habitat, instream flows, water quality, fish passage and access, and watershed or floodplain conditions that affect stream habitat. Significant actions and programs include growth management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, support of voluntary measures to restore instream flows and to protect sensitive areas, stormwater and discharge regulation, and Total Maximum Daily Load (TMDL) implementation. Responsible agencies include the Oregon Departments or Divisions of Fisheries and Wildlife, Environmental Quality, State Lands, Forestry, Agriculture, and Land Conservation and Development and the Oregon Watershed Enhancement Board. Many of these actions will have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of the listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat in the Willamette portion of the action area. These activities are likely to have cumulative effects that will significantly improve conditions for UWR Chinook and steelhead. These effects can only be considered qualitatively.

Similarly, both the states of Oregon and Washington provided information on ongoing and future or expected projects that NMFS has determined are reasonably certain to occur that are located in the lower Columbia River portion of the action area. These are similar in nature to those identified above, and will improve conditions for all of the species of salmon and steelhead considered in this Opinion.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PCEs, many of which are activities that have occurred in the recent past and have been an effect of the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area for the PA, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights) and land use practices. In the estuary and the coastal ocean, private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. Although these factors are ongoing to some extent (see Chapter 3, Rangewide Status, and Chapter 4, Environmental Baseline) and likely to

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[1] The State of Oregon identified potential constraints (e.g., funding, staffing, landowner cooperation) for many of its projects submitted as reasonably certain to occur.

continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments or in the case of pollution, additional safeguards. Therefore, although NMFS finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, it is not possible to quantify these effects.

Chapter 7
Summary of Effects of the Proposed Action on UWR Chinook & UWR Steelhead

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7 SUMMARY OF EFFECTS OF THE PROPOSED ACTION ON UWR CHINOOK & UWR STEELHEAD

SUMMARY OF THE EFFECTS OF THE PROPOSED ACTION

The predominant adverse effects of the Willamette Project are reduced viability of populations and functioning of PCEs for UWR Chinook and steelhead. This chapter summarizes the degree to which the Proposed Action would address these adverse effects.

Upper Willamette Chinook

The Proposed Action will continue to have significant adverse impacts on many Upper Willamette Chinook salmon populations and their critical habitat, in particular, effects on adult holding and spawning and juvenile rearing to the smolt stage. Additional improvements needed to mitigate for these adverse effects include:

- Fish passage above and below dams,
- Improved temperature and flow regimes below dams,
- Improved hatchery practices to minimize genetic interference, and
- Improved rearing and migration habitat.

Upper Willamette Steelhead

The Proposed Action would continue to have significant adverse effects on this steelhead population and its habitat, in particular, effects on UWR Steelhead in the North Santiam with limited stream habitat and altered water temperatures below the dams. Additional improvements needed to mitigate for these adverse effects include:

- Fish passage above and below dams,
- Improved temperature and flow regimes below dams,
- Improved hatchery practices to minimize genetic interference, and
- Improved rearing and migration habitat.

7.1 INTRODUCTION

As described in Effects of the Proposed Action (Chapter 6), the predominant adverse effects of the Willamette Project are reduced viability of populations and functioning of PCEs for UWR Chinook and steelhead. The purpose of this chapter is to summarize the degree to which the Proposed Action would address these adverse effects. This analysis summarizes information on historical effects of the project (Chapter 4, Environmental Baseline) and the analysis of effects of the Proposed Action (Chapter 5). The information in this chapter provides part of the rationale for the Conclusions for these two species in Chapter 8.

7.2 UWR Chinook Salmon

7.2.1 Current Status

Five of the seven populations in this ESU are facing critically high extinction risks and the risk of extinction is moderate even for the two populations with high numbers of natural-origin spawners (Clackamas and McKenzie; Figure 3-5). Short- and long-term trends in numbers of natural-origin fish are significantly downward for every population, with the exception of a positive short-term (20-30 years) trend for the Clackamas Chinook population. The status of PCEs of designated critical habitat for these populations is also poor, although the degree to which this habitat is deficient varies among the subbasins (see Tables 4.2-8, 4.3-4, 4.4-2, 4.5-5, 4.6-8, 4.7-4, and 4.8-1).

7.2.2 Effects of the Proposed Action on Population Viability & PCEs of Critical Habitat

NMFS' analysis of the effects of the Proposed Action in Chapter 5 included both quantitative and qualitative information with which to assess effects on the affected VSP parameters for a population and the PCEs of critical habitat. This analysis summarizes those effects in terms of the habitat requirements of two critical Chinook life stages that take place within the Willamette Basin: adult holding and spawning and juvenile rearing to the smolt stage.

7.2.2.1 Adult Holding & Spawning

Spring runs are unique among Chinook populations because they reside and mature in freshwater three to four months before spawning (Myers et al. 1998). Thus, they require cool stream temperatures, typically found in or near headwater areas where flows are predominately snowmelt driven, to survive holding and subsequently, for successful reproduction (Torgersen et al. 1999).

In the McKenzie and Clackamas watersheds, adult spring Chinook have volitional access to most of the historically occupied headwater habitat where they oversummer and spawn. These populations have exhibited the lowest prespawning mortality rates for Chinook in the Willamette Basin over a decade of study (McLaughlin et al. 2008). Both occupy large watersheds that receive substantial summertime snowmelt discharge from the headwaters of the Cascade Mountain Range. Even though some impassable dams (e.g., Blue River, Cougar, and Carmen-Smith in the McKenzie, Oak Grove in the Clackamas) were built on their tributaries, each has lost less than 5% of its historical adult holding and spawning habitat (Table 7.1). The USACE intends to construct an adult trap below Cougar Dam in 2009 and the Action Agencies propose to begin passage operations in 2010.

Three other spring Chinook populations (Middle Fork Willamette, South Santiam, and North Santiam), which historically numbered in the tens of thousands but are now at high risk of extinction, are significantly impacted by the Willamette Project. In the watersheds occupied by these populations, most of the historical holding and spawning habitat is now upstream of the Willamette Project dams. Mattson (1948) estimated that 98, 85, and 71% of the historical oversummering and spawning habitat was above the sites of Willamette Project dams built in the Middle Fork Willamette, South Santiam, and North Santiam watersheds, respectively (Table 7.1). Once the dams were built, spring Chinook were no longer able to access the cooler headwater habitats for oversummering and spawning. The remaining fish reside below the dams where prespawning mortality rates are substantial (McLaughlin et al. 2008), riparian and channel habitat conditions are significantly degraded, and seasonal water temperature regimes are altered by Project operations (see Chapter 5).

As described above, five of the seven populations have been directly impacted by the Willamette Project. There are no federal dams within the watersheds occupied by remaining two populations (Molalla and Calapooia). The headwaters for both of these watersheds are at lower elevations on the west slope of the Cascades and lack the sustained and cool late-season flows associated with watersheds that extend higher into the mountains. Historically, the Molalla and Calapooia watersheds supported relatively small Chinook populations (Nicholas 1995). Even before development, they did not have the capacity to support stronghold or core populations and their smaller populations may therefore have been even less resistant to land and water development and the historical harvest rates.

Table 7.1 Key characteristics of UWR Chinook salmon populations affected by impassable dams in the basin. Note for the Clackamas population, all dams referenced are not part of the Willamette Project, but owned and operated by Portland General Electric. In the Molalla and Calapooia populations, there are no Willamette Project dams. (NA = not available)

				Above and Below Willamette Project Dams				
ESU	Species	Population	Total Basin size (mi^2)	Percent population area lost above impassable dams (Mattson 1948)	Miles of mainstem tributary habitat downstream of lowermost impassable dam	Number of reservoirs & dams for smolts going downstream	Relative mortality in habitat below dams	Observed natural production downstream of dam(s)
UWR	Chinook	Clackamas	1503	<5	>60	2 (passable)	low	NA
		Molalla	1413	0	NA	0	NA	NA
		North Santiam	1184	>71	34	2	high	low
		South Santiam	1030	>85	36	2	medium	medium
		Calapooia	602	0	NA	0	NA	NA
		McKenzie	2092	>2	62	1	low	high
		Middle Fork	2172	98	17	4	high	low

7.2.2.2 Juvenile Rearing Habitat

Juvenile Chinook salmon require freshwater rearing areas with adequate flows and floodplain connectivity, water quality, forage, natural cover to support juvenile survival and growth and development. Juveniles also require safe passage through migration corridors to assure completion of the anadromous life cycle. As discussed in Chapter 5, in subbasins with Willamette Project dams (Coast Fork and Middle Fork Willamette, McKenzie, Long Tom, and South and North Santiam), operations alter the seasonal hydrograph and water temperatures, block the transport of gravel and large wood, and separate the channel from its floodplain. Flow operations also reduce the productivity of rearing habitat at the channel margins and ramping operations have the potential to strand and entrap fry in shallow areas. In subbasins without Project dams (Calapooia, Molalla, and Clackamas), revetments cause some of the same problems with respect to floodplain habitat and channel structure as flow operations, although these are relatively local in scale.

7.2.3 Actions Needed to Improve Population & ESU Viability & the Conservation Value of Critical Habitat

NMFS is consulting on the continued operation of the Willamette Project including the maintenance of 42 miles of revetments and the associated hatchery mitigation program, as described in Chapter 2. This section focuses on whether the Proposed Action addresses the effects of the Project by eliminating, reducing, or offsetting effects on UWR Chinook and the PCEs of critical habitat. The following is a subbasin-by-subbasin rationale for the major actions that would address the effects of the Project, based upon the assessment above and in Chapters 4 (historical effects of the Project) and 5 (effects of the Proposed Action). These actions are compared with those in the Proposed Action (Chapter 2).

Middle Fork Willamette

- The Middle Fork Willamette Chinook population is at a high risk of extinction. Key limiting factors include loss of access to 95% of the historical oversummering and spawning habitat above Willamette Project dams, elevated late-summer and fall temperatures in the mainstem below Dexter Dam and in the lower reaches of Fall Creek, and the risk of genetic introgression from hatchery-origin Chinook interbreeding with the natural-origin population.
- The limited spawning habitat below the dams does not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning and embryo mortality, premature hatching and emergence). *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for trap and haul at Fall Creek and broodstock collection below Dexter Dam must improve so that more adult Chinook survive to spawn in the high quality habitat upstream. The Supplemental BA recognizes the need for these improvements, but *the Proposed Action does not include an implementation schedule.*
- Juvenile salmon survival through the reservoirs and dams must increase, but *the Proposed Action does not set an implementation schedule for downstream passage improvements at any of the Middle Fork projects.*

- Hills Creek Reservoir will continue to be managed to meet or exceed minimum outflows and Fall Creek and Dexter reservoirs will be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Hills Creek, Lookout Point, and Fall Creek dams to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as those for flood damage reduction.

McKenzie

- The McKenzie Chinook population is at a moderate risk of extinction. It is currently the largest in the ESU, with thousands of natural-origin fish returning on average. At present, the risk of genetic introgression by hatchery-origin fish and the loss of access to historical habitat above Cougar Dam are the two key limiting factors for this population that are related to the Willamette Project.
- To protect and conserve genetic integrity within the natural-origin population, the percentage of hatchery-origin Chinook spawning with natural-origin fish must be reduced. The best location to remove hatchery fish is at Leaburg Dam, located downstream from the areas with the majority of the natural spawning. *The Proposed Action does not set an implementation schedule for constructing a trap at Leaburg Dam.*
- Historically, the South Fork of the McKenzie River produced a significant number of Chinook. All of this production was eliminated by the Willamette Project (Cougar Dam). Improvements to the adult trap-and-haul program and to downstream juvenile survival through the reservoir and dam will be necessary to sustain production over the long-term. The Proposed Action does include a commitment to build and operate a new adult trap at Cougar Dam during FY2008 (revised to 2009 due to change in construction schedule), but *does not include an implementation schedule for improving juvenile reservoir and project passage.*
- Historically, the spawning habitat in the South Fork McKenzie below Cougar Dam did not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning and embryo mortality, premature hatching and emergence). The USACE completed construction of a water temperature control tower at Cougar in December 2004 which has been fully operational since 2005. Under the Proposed Action, the Action Agencies will continue to operate the Cougar Water Temperature Control tower.
- Blue River Reservoir will continue to be managed to meet or exceed minimum outflows and Cougar Reservoir will be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently*

defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish.

- Specific hourly and daily ramp-down rates will be followed at Blue River and Cougar dams to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as those for flood damage reduction.

Calapooia

- The Calapooia Chinook population is at a high risk of extinction. The risk of genetic introgression due to a high proportion of hatchery strays spawning with natural-origin Chinook is a key limiting factor. However, all releases of hatchery-origin Chinook in the subbasin were discontinued after 2003.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

South Santiam

- The South Santiam Chinook population is at a high risk of extinction. At present, the risk of genetic introgression by hatchery-origin fish, the loss of access to 85% of the historical habitat oversummering and spawning habitat above Foster and Green Peter dams, and elevated late-summer and fall water temperatures in the mainstem below Foster are the key limiting factors for this population that are related to the Willamette Project.
- The spawning habitat below the dams will not produce significant numbers of Chinook due to the effects of elevated late-summer and fall temperatures (high prespawning mortality, premature hatching and emergence). *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for trap and haul at Foster Dam must improve so that more adult Chinook can reproduce successfully in the higher quality habitat upstream. The Supplemental BA (USACE 2007a) recognizes the need for rebuilding the Foster collection facility, but *the Proposed Action does not set an implementation schedule*.
- Juvenile Chinook survival through Foster Dam and reservoir must also increase, and passage at Green Peter must be evaluated. The Proposed Action includes continuation of a one-month spring spill program at Foster Dam, which provides higher survival than through the turbines, but *does not include measures to address reservoir and dam passage survival throughout the juvenile migration period*.
- Foster Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Foster Dam to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as flood damage reduction operations.

North Santiam

- The North Santiam Chinook population is at a high risk of extinction. The risk of genetic introgression by hatchery-origin fish, the loss of access to 71% of the historical habitat oversummering and spawning habitat above Big Cliff and Detroit dams, and elevated late-summer and fall temperatures in the mainstem below Big Cliff are the key limiting factors for this population that are related to the Willamette Project.
- Based on the number of miles available, the North Santiam River below Project dams has a high potential for re-establishing natural Chinook production. However, elevated late-summer and fall temperatures result in high prespawning and embryo mortality and premature hatching and emergence. *The Proposed Action does not include temperature control at these projects.*
- The existing facilities for broodstock collection and adult trap and haul at the Minto barrier dam must improve so that adult Chinook can be successfully outplanted in the higher quality habitat upstream. Under the Proposed Action, construction on an upgraded facility will begin in FY 2010.
- Concurrently, actions must be implemented to increase juvenile salmon survival through the Detroit and Big Cliff reservoirs and dams. The Proposed Action includes studies, but *without an implementation schedule for either the studies or for providing juvenile passage at either dam.*
- Big Cliff Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will also depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effective monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Detroit Dam to prevent desiccation of redds and entrapment and stranding of juvenile Chinook. These operations will be consistent with other project purposes such as flood damage reduction operations.

Molalla

- The Molalla Chinook population is at a high risk of extinction. The risk of genetic introgression by an out-of-basin hatchery stock is a key limiting factor for this population.
- The most important short-term action that could be taken to increase the viability of this population is to eliminate the use of an out-of-population hatchery broodstock and then to implement a better designed supplementation program for 2-3 generations to boost spawning escapement. Eventually, the hatchery program would be discontinued so that the viability of the naturally-produced population could be determined in the absence of artificial propagation. This problem is *not addressed in the Proposed Action*.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Clackamas

- The Clackamas Chinook population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Coast Fork Willamette

- The Coast Fork Willamette does not support an independent population of Chinook. Some outplanted hatchery-origin Chinook have successfully reproduced in Mosby Creek, a tributary to the Row River below Dorena Dam.
- Specific hourly and daily ramp-down rates will be followed at Cottage Grove and Dorena dams to protect juvenile outmigrants from Mosby Creek and juvenile rearing habitat in the lower reaches whenever possible, consistent with other project purposes such as flood damage reduction.

Long Tom

- Chinook use of the Long Tom is limited to juvenile Chinook rearing and overwintering.
- Specific hourly and daily ramp-down rates will be followed at Fern Ridge Dam to protect juvenile rearing habitat in the lower reaches whenever possible, consistent with other project purposes such as flood damage reduction.

Mainstem Willamette River

- The Proposed Action would continue to operate the Project to meet minimum and maximum mainstem flow objectives at Albany and Salem including both the statutorily authorized minimum flows for June through October and new “fish flow” objectives for April through June. Risks associated with meeting multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species, will be balanced during water years deemed as having “insufficient” or “deficit” volumes available.
- The Proposed Action would continue to adversely affect mainstem Willamette River Chinook rearing and migration habitat. Operation of the dams to control floods and maintaining revetments would continue to disconnect the floodplain from the mainstem river over most of its length. Aquatic habitat within the remaining stream channel is degraded by lack of complexity from large wood, sediment transport, and channelization.
- The Proposed Action includes an evaluation of floodplain restoration, but *does not include actions that would restore floodplain connections, protect the highest quality riparian habitat, or otherwise restore habitat quality in the mainstem.*
- The Proposed Action includes an evaluation of the biological impacts of revetments, but *without an implementation schedule for habitat improvement or restoration.*
- The Proposed Action includes an evaluation of the biological impacts of revetments, in the occupied subbasins and in the mainstem Willamette, but *without an implementation schedule for habitat improvement or restoration.*

Lower Columbia River, Estuary, Plume & Coastal Ocean

- Effects of the Proposed Action are limited to very small changes in river discharge with slight to negligible effects on flow-related fish habitat.

7.3 UWR STEELHEAD

7.3.1 Current Status

The four populations in the UWR steelhead DPS are currently at moderate risk of extinction (Figure 3-7). However, there are wide confidence intervals around the viability estimates for each population due to uncertainty in the data on their status (Section 3.2.2.3). Long-term trends in abundance suggest declining populations (Table 3-9), but short-term trends are positive (McElhany et al. 2007). The status of PCEs of designated critical habitat is poor, although the degree to which habitat is deficient varies among subbasins (see Tables 4.4-2, 4.5-5, 4.6-8, and 4.7-4).

7.3.2 Effects of the Proposed Action on Population Viability & PCEs of Critical Habitat

Significant differences in the life histories and habitat requirements of winter steelhead versus spring Chinook explain why the winter steelhead populations are in better shape with respect to viability. As described above, spring Chinook evolved using streams that receive substantial snowmelt from headwaters in the Cascade Mountains. They held and spawned in cold water, a component of their life-history now made difficult in several subbasins by Project dams without passage, altered thermal regimes below these dams, or both. In contrast, winter steelhead, migrate to their natal streams in late winter/early spring and spawn almost immediately. Spawning streams range in size from very small streams to larger rivers. With spawning and rearing distributed over a larger area, the adverse effects of Willamette Project influence a smaller proportion of each steelhead population’s habitat than is the case for spring Chinook.

Two of the four steelhead populations in the Upper Willamette River DPS are directly affected by Willamette Project dams and reservoirs. The North Santiam and South Santiam are large watersheds, and the steelhead in these tributaries were identified as “core” populations by the WLCTRT. The other two subbasins supporting independent populations of UWR steelhead (Molalla and Calapooia) do not contain large, high-head, USACE dams, but experience minor effects of the Project due to maintenance of revetments.

The South Santiam steelhead population currently ranks as having the lowest risk of extinction in the DPS. The South Santiam has the largest amount of steelhead habitat volitionally accessible, with over 930 miles of stream habitat accessible below and above Foster Dam (Maher et al. 2005). Most of this spawning and juvenile rearing habitat is located in tributaries to the South Santiam River below the Project dams (Thomas, Crabtree, and Wiley creeks). In addition, the trap and haul program for natural-origin steelhead at Foster Dam has been in operation since the dam was constructed, which has allowed steelhead to use the historical habitat upstream for natural production. Even though the upstream passage facilities at Foster Dam need upgrading to reduce rates of injury and mortality (Section 4.5.3.1), some of these adults spawn successfully because significant numbers of steelhead smolts emigrate downstream. Improvements to the upstream and downstream passage facilities and operations at Foster Dam would increase the productivity of the natural-origin steelhead spawning in the upper South Santiam as well as the survival of kelts migrating back to the ocean.

In contrast, steelhead in the North Santiam only have access to about 400 miles of stream habitat, all below Detroit and Big Cliff dams. Almost 620 miles of historical stream habitat above Big Cliff/Detroit dams (Maher et al. 2005) are currently inaccessible, but no steelhead are passed upstream. Other than the mainstem below these dams, only one large tributary, the Little North Santiam River, provides significant steelhead habitat. The continued operation of the Willamette Project under the Proposed Action would continue to exclude steelhead from much of the historical habitat above Detroit/Big Cliff dams and to expose incubating eggs and young fry to colder water temperatures below the dams, which delays emergence and reduces growth.

The Molalla and Calapooia populations face a different suite of limiting factors and threats compared to those in the Santiam system (see Chapter 4 and ODFW 2007a). The Calapooia subbasin is relatively small and thus steelhead habitat is relatively limited. In addition, the lower elevations of the Calapooia are surrounded by agricultural land (Maher et al. 2005). Land management activities associated with timber harvest and agriculture are the primary threats to this population. A similar situation exists in the Molalla subbasin. However, the Molalla is a much larger watershed, which currently has over 870 miles of stream habitat available to steelhead (Maher et al. 2005) and therefore a much greater production potential. For both of these populations, protection of the highest quality remaining habitat, combined with habitat restoration, will be necessary to improve their status. Incidental fishery harvest rates (typically 1-3%, including hook-and-release mortality) are already reduced to a very low level.

7.3.3 Actions Needed to Improve Population & DPS Viability & the Conservation Value of Critical Habitat

This section focuses on whether the Proposed Action addresses the effects of the Project by eliminating, reducing or offsetting effects of UWR steelhead and the PCEs of critical habitat. The following is a subbasin-by-subbasin rationale for the major actions that would address the effects of the Project, based upon the assessment above and in Chapters 4 (historical effects of the Project) and 5 (effects of the Proposed Action). These actions are compared with those in the Proposed Action (Chapter 2).

Calapooia

- The Calapooia steelhead population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, but there are no Project dams in the subbasin.

South Santiam

- The South Santiam steelhead population is at a moderate risk of extinction and is one of the largest in the DPS. The trap and haul program at Foster Dam has allowed natural-origin fish to continue to use most of their historical upstream habitat (although approximately 17% remains blocked by Green Peter Dam).

- The ladder, trap, and methods for handling fish at the collection facility at Foster Dam cause delay, injury, and stress. These problems are compounded by the overlap in run timing of natural-origin steelhead with those of hatchery Chinook and steelhead. The facility therefore must be upgraded to allow more efficient capture and handling of listed steelhead. The Supplemental BA (USACE 2007a) recognizes the need for rebuilding the Foster Trap, but the Proposed Action *does not set an implementation schedule*.
- Actions must also be taken to increase downstream juvenile steelhead and kelt survival through Foster Reservoir and Dam. The Proposed Action includes continuation of a one-month spring spill program at Foster Dam, which provides higher survival than through the turbines, but *does not include measures to address reservoir and dam survival throughout the juvenile migration period and when kelts are likely to be moving downstream*.
- Colder than normal water temperatures during spring delay hatching and emergence of juvenile steelhead in the mainstem South Santiam below Foster. The Proposed Action *does not include temperature control at Green Peter or Foster Dam*.
- Foster Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat and eggs deposited during spawning. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Foster to prevent entrapment and stranding of juvenile steelhead. These operations will be consistent with other project purposes such as flood damage reduction operations.
- The risks to population viability associated with the hatchery summer steelhead program must be reduced. The Proposed Action includes studies of the proportion of natural-origin juvenile steelhead that are the progeny of summer steelhead and a commitment to assess the summer steelhead recycling protocol, but lacks the specific measures needed to address these problems.

North Santiam

- The North Santiam steelhead population is currently at a moderate risk of extinction. Key threats and limiting factors related to the Willamette Project include loss of access to historical spawning and rearing habitat above Big Cliff/Detroit dams and risks associated with the out-of-basin summer steelhead hatchery program.
- Unmarked winter steelhead captured at Minto are released upstream of the barrier dam, but below Big Cliff. Cold water temperatures during spring delay hatching and emergence and elevated gas levels from flow operations can adversely affect the eggs, larvae, and fry. The Proposed Action *does not include temperature control at Detroit/Big Cliff dams or measures to reduce the frequency and duration of elevated gas levels*.
- At present, steelhead have not been reintroduced back into historical habitat blocked by Project dams. A risk/benefit assessment should be completed to assess whether reintroduction efforts would increase the viability of this population *but the Proposed Action does not include a commitment to this effort*.

- Big Cliff Reservoir will continue to be managed to meet minimum and maximum outflows, protecting adult access to downstream spawning habitat, eggs deposited during spawning, and rearing habitat. These operations will depend on available reservoir storage and inflow and will be consistent with flood damage reduction and public safety requirements. The Proposed Action includes compliance and effectiveness monitoring for instream flows, *but insufficiently defines NMFS' role in ensuring that any changes in these objectives meet the habitat needs of anadromous fish*.
- Specific hourly and daily ramp-down rates will be followed at Detroit Dam to prevent entrapment and stranding of juvenile steelhead. These operations will be consistent with other Project purposes such as flood damage operations.
- The risks to population viability associated with the hatchery summer steelhead program must be reduced. The Proposed Action includes studies of the proportion of natural-origin juvenile steelhead that are the progeny of summer steelhead and a commitment to scale back summer steelhead recycling efforts no later than 2008, which will reduce the potential for adverse interactions with native winter steelhead.

Molalla

- The Molalla steelhead population is at a moderate risk of extinction.
- Habitat in the lower reaches is affected by revetments, which reduce the functioning of rearing habitat, but there are no Project dams in the subbasin.

Mainstem Willamette River

- The Proposed Action would continue to operate the Project to meet minimum and maximum mainstem flow objectives at Albany and Salem including both the statutorily authorized minimum flows for June through October and new "fish flow" objectives for April through June. Risks associated with meeting multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species, will be balanced during water years deemed as having "insufficient" or "deficit" volumes available.
- The Proposed Action would continue to adversely affect mainstem Willamette River steelhead rearing and migration habitat. Operation of the dams to control floods and maintaining revetments would continue to disconnect the floodplain from the mainstem river over most of its length. Aquatic habitat within the remaining stream channel is degraded by lack of complexity from large wood, sediment transport, and channelization.
- The Proposed Action *does not include actions that would restore floodplain connections, protect the highest quality riparian habitat, or otherwise restore habitat quality in the mainstem*.
- The Proposed Action includes an evaluation of the biological impacts of revetments, in the occupied subbasin and in the mainstem Willamette, but *without an implementation schedule for habitat improvement or restoration*.

Lower Columbia River, Estuary, Plume, and Coastal Ocean

- Effects of the Proposed Action are limited to modest changes in river discharge and changes in flow-related fish habitat. While small, these effects affect all of the species considered in this Opinion, including UWR steelhead.

- Effects of the Proposed Action add to much larger effects of other water developments in the Columbia basin on fish and fish habitat in the lower Columbia River, estuary, and plume.

7.4 Summary of Effects of the Proposed Action on UWR Chinook Salmon & UWR Steelhead

The Proposed Action does not adequately address the effects of the Willamette Project on UWR Chinook or steelhead. Principal deficiencies are:

- Chinook and steelhead populations important to the viability of their respective ESU/DPSs will be limited to use degraded spawning and rearing habitat below Project dams where space, water temperatures, and physical habitat conditions do not meet the species biological requirements
- Inadequate plan for upgrading adult collection facilities
- No plan for developing adequate downstream passage facilities for juveniles of either species and for steelhead kelts
- Lack of measures to improve rearing habitat affected by Project revetments
- Inadequate plan for reducing straying of hatchery-origin UWR Chinook into the area reserved for natural production above Leaburg Dam in the McKenzie subbasin
- Lack of specific measures to address the adverse effects of the summer steelhead hatchery program on listed fish

NMFS considers these deficiencies in its jeopardy analyses for UWR Chinook and steelhead in Sections 8.1 and 8.2.

7.5 Summary of Effects of the Proposed Action on Critical Habitat for UWR Chinook and UWR Steelhead

The Proposed Action does not adequately address the effects of the Willamette Project on critical habitat for UWR Chinook or steelhead. Principal deficiencies are:

- Spawning and rearing habitat will not have adequate water quality, floodplain connectivity, forage, and natural cover for the conservation of the species
- Inadequate plan for providing safe passage at adult collection facilities
- No plan for developing safe downstream passage facilities for juveniles of either species
- Lack of measures to improve floodplain connectivity and natural cover in rearing habitat affected by Project revetments

NMFS considers these deficiencies in its adverse modification (of critical habitat) analyses for UWR Chinook and steelhead in Sections 8.1 and 8.2.

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Chapter 8
Conclusions

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8 CONCLUSIONS

The standards for determining jeopardy are set forth in Section 7(a)(2) of the ESA as defined by 50 C.F.R. Part 402 (the consultation regulations). Procedures for conducting consultation under section 7 of the ESA are further described in the Services' Consultation Handbook (USFWS and NMFS 1998). Jeopardy is defined as to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. Therefore it must determined, (a) whether the species can be expected to survive with an adequate potential for recovery under the effects of the action, the effects of the environmental baseline, and any cumulative effects, and (b) whether affected designated critical habitat is likely to remain functional (or retain the ability to become functional) to serve the intended conservation role for the species in the near and long term under the effects of the action, environmental baseline and any cumulative effects.

The analysis in the preceding sections of this Biological Opinion forms the basis for conclusions as to whether the Proposed Action, the ongoing operation and maintenance of the Willamette Project, including the mitigation hatchery program and maintenance of 42 miles of revetments, satisfies the standards of ESA Section 7(a)(2). To satisfy those standards, the Proposed Action must not be likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Chapter 3 of this opinion defines the current status of each of the 13 listed salmonid species and the status of critical habitat designated for 12 of the salmonid species. Chapter 4 evaluates the condition of the environmental baseline. Chapter 5 describes the likely effects of the Proposed Action on habitat condition, critical habitat, and the abundance, productivity, spatial structure, and genetic diversity of populations in the action area. Chapter 6 considers the cumulative effects of relevant non-Federal actions reasonably certain to occur within the action area. Chapter 7 synthesizes all of the relevant information in the baseline, effects, and cumulative effects chapters to assess effects of the Proposed Action on the listed species as a whole across its range and life cycle, and effects on designated critical habitat. On the basis of this information and analysis, NMFS draws its conclusions about the effects of the Proposed Action for the Willamette Project on the likelihood of survival and recovery of the 13 listed salmonid species that occupy the action area, and the likelihood that the Proposed Action will destroy or adversely modify designated critical habitat.

8.1 UPPER WILLAMETTE RIVER CHINOOK SALMON

Currently, the UWR Chinook ESU is at a high risk of extinction. Numbers of natural-origin spawners are low and long- and short-term productivity trends are negative. Five of the seven populations are at a very high risk of extinction. Primary limiting factors have been flood control and hydropower, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. Total allowable harvest rates are 12% in the ocean and 15% in freshwater fisheries.

Within the freshwater portion of the action area, the species' viability (as described by the abundance, productivity, spatial structure, and genetic diversity of its component populations) has been limited by factors associated with the Willamette Project: flood control and hydropower operations have prevented access to historical habitat; water storage contracting has exacerbated poor habitat and altered natural water temperature patterns; and large numbers of hatchery-origin fish spawning with those of natural origin have created a risk of genetic introgression. Other threats include land use, especially the development of low elevation riparian areas for agriculture and urbanization and operations at FERC-licensed projects on the mainstem Santiam River and in the McKenzie basin. The former will continue into the future, although non-federal habitat-related actions and programs that NMFS has determined are reasonably certain to occur will minimize adverse effects. Conditions at the FERC projects are improving based on section 7 consultations in recent years.

Within the lower Columbia River and estuary (i.e., below the confluence of the Willamette), used for rearing by subyearling Chinook from this ESU, riparian and wetland functions have been reduced by Federal Columbia River Power System (FCRPS) flow management. The 2008 FCRPS RPA (NMFS 2008a) requires the implementation of habitat projects that address limiting factors (e.g., protecting and restoring riparian areas, protecting remaining high quality off-channel habitat, breaching or lowering dikes and levees to improve access to off-channel habitat, and reducing noxious weeds). The sport reward fishery for Northern pikeminnow will continue to control this predator, and Caspian terns will be relocated from the estuary. However, predation by other colonial waterbirds such as double-crested cormorants and by pinnipeds will continue. In the coastal ocean, ongoing private activities include construction and associated marine pollution.

Under the Proposed Action, many of the significant adverse effects on the species and its critical habitat in the freshwater portion of the action area, which contributed to its current high risk of extinction, will continue without providing needed measures including effective passage, or adequate temperature control. In addition, the Proposed Action will continue the adverse effects on the functioning of PCEs that have impaired the ability of critical habitat to serve its conservation role for the species. Therefore, NMFS concludes that the proposed operation of the Willamette Project and associated hatchery mitigation program are likely to jeopardize the continued existence of this ESU and to destroy or adversely modify its designated critical habitat.

8.2 UPPER WILLAMETTE RIVER STEELHEAD

Currently, the UWR steelhead DPS is at a moderate risk of extinction. Numbers of natural-origin spawners are moderate and short-term trends in productivity are upward. Primary limiting factors have been flood control and hydropower, hatcheries, harvest, habitat degradation (tributary, mainstem, and estuarine), predation, and ocean and climate conditions. Ocean harvest is assumed to be zero and less than 2% of natural-origin fish are harvested in freshwater.

Limiting factors and effects of the proposed action on the species and its habitat are similar to those described above for UWR Chinook salmon. In this case, two of the four populations occupy watersheds where habitat has been significantly degraded by Willamette Project operations. The Proposed Action will continue to prevent access to some of the important areas used historically for spawning, incubation, and larval growth and development and will impair of water quantity and quality. The Proposed Action will also continue hatchery practices that represent substantial risk to the development of self-sustaining populations. The improvements implemented under the Proposed Action will not provide needed measures including effective passage, or adequate temperature control.

When taking into account the current status of the species and its critical habitat, the degraded condition of the environmental baseline, and cumulative effects, the Proposed Action will not address the effects of the Willamette Project such that the DPS is likely to survive with an adequate potential for recovery. In addition, the Proposed Action will continue the adverse effects on the functioning of PCEs that have impaired the ability of critical habitat to serve its conservation role for the species. Therefore, NMFS concludes that the Proposed Action is likely to jeopardize the continued existence of this DPS and to destroy or adversely modify its designated critical habitat.

8.3 Lower Columbia River Steelhead, Chinook Salmon & Coho Salmon

All of the populations in these listed DPS and ESUs spawn outside the action area, but use the habitat in the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, for rearing (for Lower Columbia River Chinook populations with subyearling migrants) and during their adult and juvenile migrations. Within the action area, the viability of these species has been limited by harvest, hatchery production, land management practices, the effects of the FCRPS, and the operations of other federally- and privately-owned hydroprojects, including water diversions and are further threatened by potential climate change and adverse ocean conditions (NMFS 2008a). With respect to the FCRPS, effects on these species are addressed by the 2008 FCRPS RPA (NMFS 2008a); many of the adverse effects of the FERC-licensed hydroprojects also have been addressed in recent consultations (Sections 3.2.3.1 through 3.2.3.3). Proposed Willamette Project flow operations could reduce the quantity and quality of rearing habitat in the lower river, estuary, and plume, including critical habitat designated for two of these species. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and their critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Lower Columbia River Chinook, steelhead, or coho salmon, nor adversely modify or destroy critical habitat designated for Lower Columbia River Chinook or steelhead.

8.4 Columbia River Chum Salmon

Columbia River chum salmon spawn outside the action area but use habitat in the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume for rearing and during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management practices and the effects of the Federal Columbia River Power System (FCRPS), which have impaired water quality and quantity, forage, riparian vegetation, and space in estuarine areas used for growth and development. The species is threatened by potential climate change and adverse ocean conditions. The effects of the FCRPS are addressed by the 2008 FCRPS RPA (NMFS 2008a). Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Columbia River chum salmon nor adversely modify or destroy its designated critical habitat.

8.5 MIDDLE COLUMBIA RIVER STEELHEAD

All of the populations in this DPS spawn outside the action area, but occupy the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (NMFS 2008a), which contributed to the loss of riparian cover. Steelhead are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and the species is further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Middle Columbia River steelhead nor adversely modify or destroy its designated critical habitat.

8.6 SNAKE RIVER STEELHEAD, SPRING/SUMMER CHINOOK SALMON, FALL CHINOOK SALMON & SOCKEYE SALMON

All of the populations in these ESUs spawn outside the action area, but occupy the lower Columbia River in the action area from the mouth of the Willamette downstream to the estuary plume during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (addressed by the FCRPS RPA [NMFS 2008a]), which contributed to the loss of riparian function. Steelhead, Chinook, and sockeye are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and these species are further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat for these species, but these effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and its critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Snake River steelhead, sockeye salmon, spring/summer or fall Chinook salmon, nor adversely modify or destroy their designated critical habitat.

8.7 UPPER COLUMBIA RIVER STEELHEAD & CHINOOK SALMON

All of the populations in the Upper Columbia River steelhead DPS and Chinook ESU spawn outside the action area, but occupy the lower Columbia River, from the confluence of the Willamette downstream to the estuary and plume, during their adult and juvenile migrations. Within the action area, the viability of the species has been limited by land management activities and FCRPS operations (addressed by the 2008 FCRPS RPA [NMFS 2008a]), which contributed to the loss of riparian function. Steelhead and Chinook are susceptible to predation by colonial waterbirds, fish, and pinnipeds, and these species are further threatened by potential climate change and adverse ocean conditions. Proposed Willamette Project flow operations could affect the quantity and quality of rearing habitat in the lower river, estuary, and plume, including designated critical habitat. These effects are likely to be minor because flows from the Willamette River are a relatively small proportion of those in the lower Columbia. Therefore, when taking into account the current status of the species and their critical habitat, the condition of the environmental baseline within the action area, and cumulative effects, NMFS concludes that the Proposed Action is not likely to jeopardize the continued existence of Upper Columbia River steelhead or Chinook salmon nor adversely modify or destroy their designated critical habitat.

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Chapter 9
Reasonable & Prudent Alternative

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9 REASONABLE & PRUDENT ALTERNATIVE

INTRODUCTION

In Section 8, NMFS concluded that the Proposed Action would jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and destroy or adversely modify their designated critical habitat. NMFS reached no jeopardy and no adverse modification conclusions for the 11 other listed salmonid species, and NLAAs for green sturgeon and southern resident killer whale. Therefore, NMFS is providing the Action Agencies with the following reasonable and prudent alternative (RPA) to avoid jeopardizing the continued existence of UWR Chinook salmon and UWR steelhead, and avoid destroying or adversely modifying their critical habitat, as required by ESA section 7(b)(3)(A).

An RPA is an action, identified during formal consultation, that can be carried out consistent with the purpose of the action, is within the scope of the action agency's legal authority, is economically and technologically feasible, and would avoid jeopardy to listed species and the destruction or adverse modification of designated critical habitats (50 CFR 402.02). The measures NMFS is providing in the RPA fit the regulatory requirements of an RPA. The measures fall into the general categories of substantive measures for fish passage, water quality, flows, water contracts, habitat, and hatcheries. There are also measures for coordination, studies, and monitoring related to the substantive measures. These measures have time frames for each action. The RPA measures are within the project purposes because fish and wildlife protection is a project purpose. The Action Agencies have legal authority to carry out these measures because the statutes that authorize the project include project purposes for fish and wildlife protection, and in some cases already include specific provisions for some of the measures.

These general categories of the measures in the RPA, fish passage, water quality, flow, water contracts, habitat, and hatcheries, are all measures in the PA that, when considered with the environmental baseline and cumulative effects and the rangewide status of UWR Chinook salmon and UWR steelhead, did not result in survival with an adequate potential for recovery for these species. In addition, they were inadequate to avoid the destruction or adverse modification of designated critical habitat. NMFS' RPA includes the measures in the PA, adds new measures, and modifies others in the PA. A general concept behind most of NMFS additional measures and modifications is to build on the studies in the PA by adding on-the-ground measures that the Action Agencies will complete to address Project effects on listed anadromous fish. Therefore, NMFS' RPA specifically lists measures that the Action Agencies will carry out after the necessary studies and designs are completed to verify feasibility. NMFS' assessment of effects regarding the RPA's avoidance of jeopardy and destruction or adverse modification of critical habitat is based on the benefits attributed to successful completion of these measures.

Structural and operational changes at Project dams and improvements in Action Agency programs that affect salmonid habitat downstream of the dams and that allow upstream and downstream fish passage are needed to address the effects of the Willamette Project, thereby increasing the viability of the affected populations and the functioning of the PCEs of their designated critical habitat. Specifically, construction and operation of new facilities for effective up- and downstream fish passage at Project dams, installation of water temperature control

(WTC) at Project dams, more normative discharge patterns downstream of these dams, mitigation of ongoing effects of the dams and continued existence and maintenance of revetments on the physical characteristics of downstream salmonid habitats, and hatchery programs more strongly focused on species conservation, are needed to address project effects on listed fish in multiple subbasins. The Action Agencies' proposed measures in the PA provide improvements to the existing system and operations, but do not adequately address project effects on listed fish and their habitat. Many of those measures lacked deadlines for beginning and completing work. This lack of certainty and specificity was one of the reasons that NMFS made the jeopardy and adverse modification of critical habitat determinations in Section 8. Another reason was that there were not enough specific on-the-ground measures to adequately address project effects and avoid jeopardy and destruction and adverse modification of critical habitat. In order to assure timely progress toward implementing critical on-the-ground actions, NMFS' RPA establishes deadlines for completing studies, structural and operational improvements at the dams and hatcheries, and for implementing habitat restoration programs. Specific projects are identified that must be completed in the short term, while other, larger projects must be completed during later years of the term of the Opinion. In the RPA, certain specific fish passage and temperature control measures will be completed by 2023, the end of the Opinion term. Additionally, significant progress will be made toward identifying future passage and temperature control measures that could be implemented after 2023 under a subsequent consultation.

A number of the RPA measures will provide benefits in the short-term, reducing each species' short-term risk of extinction, including measures to improve downstream habitat by changing flows and temperature, updating hatchery operations and facilities, improving irrigation diversions and water contracts, upgrading fish collection facilities and outplanting procedures, and conducting habitat improvement projects. These measures will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the short-term risk of extinction. This is especially important for UWR Chinook salmon, for which the risk of extinction is "high."[1] Project operations have had a key role in degrading habitat conditions downstream, which in the North and South Santiam, South Fork McKenzie, and Middle Fork Willamette are the only areas still accessible to Chinook for spawning, incubation, and early rearing. The Action Agencies began new reservoir operations in 2000 to meet mainstem and tributary flow objectives for both listed Chinook and steelhead. These, and operations that began in 2005 at the new Water Temperature Control facility at Cougar Dam, are already able to have a positive influence on adult Chinook returns. Under the RPA, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and pre-spawning adults of both species and thus population productivity. All of these measures will reduce extinction risk in the short term as well as contributing to long-term viability.

Decision-making for all of the final actions and implementation of measures included in the RPA must comply with all applicable statutes and regulations. Among those the Action Agencies must consider are NEPA, the Clean Water Act and the Northwest Power Planning Act. In so doing, the criteria the Action Agencies will apply are whether the action is: (1) biologically feasible and

[1] The WLCTRT (McElhany et al. 2007) estimated the risk of extinction over 100 years for UWR Chinook ("high;" see Figure 3-5 in Section 3.2.1.3). The TRT did not estimate the species' short-term extinction risk.

beneficial; (2) technically feasible; and (3) cost effective. These criteria would not necessarily apply to interim decision points and to information gathering requirements. In addition, the Action Agencies' Configuration/Operation Planning (COP) study process will outline the costs of specific projects, their biological benefits, and a reasonable array of potential alternatives to achieve the desired results.

The measures in this RPA are additive to the Action Agencies' Proposed Action (USACE 2007a). That is, the two sets of measures combined create the complete RPA that NMFS will analyze. For the sake of brevity, the RPA measures provided below only include measures that are not in the PA, and PA measures that are changed in some way. In the event there are inconsistencies between the PA and RPA, this RPA will take precedence.

9.1 COORDINATION

The RPA measures in this section are based on Section 3.1 of the Supplemental BA (USACE 2007a). In that section, the Action Agencies propose to organize the WATER group, prepare a charter, and establish various subcommittees. In recent years, the USACE has informally coordinated flow management and project operation issues with other federal agencies, state agencies, local government, and other organizations, but there were no guidelines for how this coordination should take place or what would happen if technical participants could not agree. The Action Agencies proposed the WATER group to formalize this process and to ensure consistent coordination and decision-making. NMFS supports the Action Agencies' proposal, but we include it here with minor revisions to clarify the decision-making process and agency roles. This clarification is needed in the RPA because most of the actions that will be taken to avoid and minimize effects on listed salmonids and critical habitat rely on either in-season management (mainstem and tributary flows, response to emergency operations), review of RM&E studies (e.g., downstream fish passage measures) and review of engineering design alternatives (e.g., adult fish collection facilities, temperature control facilities. In order to ensure these ongoing decisions are implemented in a fashion consistent with the analysis in this Opinion, the following measures are needed:

RPA 1 Coordination

1.1 **<u>Charter of WATER</u>: By December, 2008, the Action Agencies, in coordination with the Services, other federal and state agencies with fisheries and water resource management responsibilities in the Willamette River Basin, and affected Tribes, will complete a Charter for a collaborative advisory body to be known as the Willamette Action Team for Ecosystem Restoration (WATER). Once the Charter is completed, the Action Agencies will coordinate with the WATER on operation of the Willamette Project consistent with the Charter. The WATER will be a formalized, collaborative body to advise the Action Agencies in the coordinated implementation of the environmental protection and conservation measures described in the Proposed Action, RPA, and other actions that may develop while operating the project.**

Rationale/Effect of RPA 1.1: This measure clarifies that the Action Agencies and the Services, other federal agencies, state agencies, and tribes will complete a charter for WATER by December, 2008, and will operate according to the charter. The Proposed Action had stated it would be done within one year of completion of the Supplemental BA (i.e., by June 2008), but that date has now passed.

The effect of this measure will be to improve and inform the Action Agencies' and Services' decision making, provide a forum for various points of view, share scientific and technical information, and coordinate actions by the parties. This coordination and sharing of information will ultimately reduce the time needed to address the effects of the Project on population viability and the functioning of PCEs of designated critical habitat.

1.2 **<u>Technical Sub-Committees of WATER</u>: The Action Agencies will establish technical coordinating committees as part of the WATER to provide review and recommendations of Action Agencies' products. Technical experts from applicable state agencies and the Tribes may participate on committees based on the subject matter of each committee and the scope of each organization's respective areas of responsibility and expertise. Other parties may participate on the subcommittees depending on the subject area and agreement by the Action Agencies and Services. The number, responsibilities, and scope of the technical committees formed will be determined by the Action Agencies and the Services through development of a charter for WATER. However, at a minimum, these will address flow management; fish passage and hatchery management; environmental coordination for construction projects; water quality/temperature control; habitat restoration; and research, monitoring, and evaluation.**

Rationale/Effect of RPA 1.2: NMFS adds this measure in place of the detailed description of each subcommittee proposed by the Action Agencies in Section 3.1 and Figure 3-1 of the Supplemental BA (USACE 2007a). The specific number, function, and membership of each subcommittee should be developed through development of the charter rather than pre-supposed in the Proposed Action. While NMFS encourages active participation by a variety of organizations and individuals on these issues, timely decisions on fish protection measures such as fish passage facilities and necessary RM&E to support those decisions need to be made by entities with fish management authority. The charter must be clear that the committees will play an advisory role only and will not replace the Action Agencies' responsibilities to carry out measures required by the Proposed Action and this RPA.

1.3 **<u>WATER Decision-Making Process</u>: The Action Agencies will ensure that the Charter for WATER and its technical coordinating committees describes a decision-making process that recognizes the unique role played by NMFS and USFWS in decisions related to measures covered in their respective Biological Opinions. In this process, the Action Agencies will prepare initial proposals for operations, studies, or structural changes and will seek review and comment by the applicable WATER subcommittee. Committee members, including NMFS and USFWS, will provide feedback to the Action Agencies within a maximum 60-day period, or less,**

depending on the magnitude and complexity of the proposal. The Action Agencies will then modify the proposal as they determine necessary to address committee members' comments and to meet their ESA responsibilities. NMFS or USFWS (or both, depending on the subject and what species might be affected) will review the final document and inform the Action Agencies whether they agree with it. If NMFS or USFWS disagrees with a proposal based on concerns that the proposal may adversely affect species within their respective authorities or be inconsistent with their respective Biological Opinions[2], the Action Agencies will either modify the proposal to address the Services' concerns, elevate the decision following a process described in the Charter, or seek reinitiation of consultation.

Rationale/Effect of RPA 1.3: This measure specifies that the WATER process must use this decision-making process to ensure that measures required by this Opinion are carried out effectively and in a timely manner, with adequate opportunity for review and comment. The Action Agencies retain ultimate responsibility for completing required actions. Adaptive management decisions need to be made with written supporting documentation. NMFS and USFWS will inform the Action Agencies whether they agree or disagree with the decisions, or if specific decisions are inconsistent with their respective Opinions. If the NMFS or FWS disagree, the Action Agencies must either modify decisions, seek dispute resolution, or reinitiate consultation.

1.4 **Role of Services in decision-making (agreement with Action Agencies): The Action Agencies will provide NMFS, USFWS, or both, as appropriate depending on the action and species affected, with draft documents for comment. The Action Agencies will address comments received from NMFS and USFWS when finalizing a document. If the Services do not agree with the final document, then they will elevate the issues for resolution, if appropriate.**

Rationale/Effect of RPA 1.4: This new measure is needed to clarify that the Services play a unique role during the implementation phase of measures required by their respective Opinions. Unlike many other Section 7 ESA consultations that address specific, short-term projects and that require specific mitigation measures that are used during and directly after construction, this consultation involves many measures that are not clearly defined yet and are awaiting study results and design feasibility analyses before specific decisions can be made. For instance, in the fish passage measures below (section 9.4), NMFS requires that downstream fish passage be carried out at Cougar Dam by a specific year, but until field studies are completed and design alternatives analyzed, NMFS cannot predict what sort of system or set of operations this will be. NMFS anticipates that it will be closely involved in review of all facets of these studies and analyses to ensure that decisions made are consistent with the statement and intent of this Opinion. The effect of this dispute resolution provision will be to preserve both the Action Agencies' and Services' authorities.

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[2] This measure does not broaden either of the Services authority to engage in issues outside of each agency's authority, except that it does provide for both agencies to engage in issues that affect species listed by both agencies.

9.2 FLOW MANAGEMENT

The measures in this section are based on Section 3.3 of the Supplemental BA (USACE 2007a). In that section, the Action Agencies propose to do the following: 1) organize a Flow Management Committee of the WATER group; 2) develop a protocol for notification when Project operations cause deviations from flow and ramping objectives; 3) operate to make every effort to meet or exceed minimum mainstem Willamette flow objectives; 4) operate to make every effort to meet or exceed minimum tributary flow objectives; 5) operate to follow hourly and daily ramp-down rates under normal operating conditions; 6) release spill at Foster Dam during spring for downstream fish passage; and 7) develop and carry out a comprehensive RM&E program to evaluate and monitor these flow management actions.

NMFS generally supports the Action Agencies' flow management proposals, but the following measures are needed to improve the decision-making process, increase the likelihood and frequency of meeting flow and ramping rate objectives, and define agency roles. This clarification is needed in the RPA because most of the actions that will be taken in the short-term to avoid and minimize effects on listed salmonids rely on either in-season management (mainstem and tributary flows, response to emergency operations), review of RM&E studies (e.g., downstream fish passage measures) and review of engineering design alternatives (e.g., adult fish collection facilities, temperature control facilities).

RPA 2 Flow Management

2.1 **<u>WATER Flow Management Committee</u>: The USACE will establish a Flow Management (FM) Committee under WATER to advise USACE on streamflow management issues related to operation and maintenance of the Willamette Project. The USACE will take a leadership role in the administration of this committee, providing for coordination, administration costs, and meeting space. The USACE, with review by the FM Committee, will develop and implement the annual Willamette Conservation Plan,[3] and coordinate on all issues related to listed fish with the Services and with Federal and state agencies, Tribes, and entities throughout each flow management season.**

Rationale/Effect of RPA 2.1: This measure modifies a similar action described in section 3.3.3 of the Supplemental BA (USACE 2007a) by assigning responsibility for managing and funding the committee to the USACE. The role of the committee is advisory to the USACE. Coordination throughout the flow management season should maximize benefits to listed fish, consistent with authorized Project purposes and giving due consideration to the relative importance of each.

The effect of this measure will be to improve decision-making regarding flow management and ensure that the USACE will operate the Project to minimize adverse Project effects on listed fish, consistent with other authorized Project purposes.

[3] The Annual Willamette Conservation Plan is reviewed and revised each year. It describes minimum and maximum mainstem and tributary flow objectives that guide the Action Agencies' operation of the 13-dam Willamette Project, and it includes specific operational priorities for the given year.

Indirectly, this measure will help improve survival of juvenile and adult fish during migration through the mainstem Willamette and Project-affected tributaries by ensuring that timely decisions regarding Project flow releases are made and issues quickly resolved during in-season management. Likewise, this measure will help improve productivity of UWR Chinook salmon and UWR steelhead that spawn below Project dams by ensuring that local biologists are queried to provide real-time data regarding fish presence and that timely decisions are made to reduce impacts to redds once adults have spawned.

2.2 **Protocol for Notification of Deviations: The Action Agencies will notify the Services when turbine units, regulating outlets, and spillway gates malfunction or are placed out of service for an emergency which results in an unscheduled outage that may have an impact on ESA-listed fish species. The Action Agencies will follow the notification protocol described in RPA measure 4.3 (Willamette Fish Operations Plan) below.**

Rationale/Effect of RPA 2.2: This measure is described in RPA measure 4.3 below.

2.3 **Minimum Mainstem Flow Objectives: The USACE will operate the system in a manner to meet or exceed minimum mainstem flow objectives listed in Table 9.2-1 as measured at Salem and Albany, Oregon, following the framework described in Appendix D and in collaboration with the Services and other entities as provided in RPA measures 1 and 2.1. Based on RM&E results (RPA measure 9 in section 9.9 below) and operational experience, and with the approval of the Services and review by the FM Committee, the USACE will amend mainstem flow objectives (Table 9.2-1) in its Annual Willamette Conservation Plan.**

Rationale/Effect of RPA 2.3: This measure is based on a similar action described in section 3.3.5 of the Supplemental BA (USACE 2007a). The minimum mainstem flow objectives are the same as in the Proposed Action, and NMFS adopts Appendix D, which recognizes that these flow objectives will likely not be met in water years that are not "adequate" or "abundant" as defined in Appendix D. The primary difference from the Proposed Action measure is that this measure requires approval by the Services of any changes in Table 9.2-1 flow objectives, while the Proposed Action simply required the Action Agencies to consider recommendations from NMFS and other FM Committee members.

The effect of this measure is that it will better ensure adequate flows for UWR Chinook salmon and UWR steelhead that migrate and rear in the mainstem Willamette River than provided by the Proposed Action. In the Mainstem Willamette Effects section 5.10, NMFS found that the proposed mainstem flow objectives were sufficient based on existing data. These flow objectives would be expected to aid downstream migration of juvenile steelhead by reducing the likelihood of disease outbreaks based on flow and water temperature relationships. Additionally, minimum flow objectives during summer months would provide water quality benefits to rearing juvenile Chinook and steelhead and upstream migrating adult Chinook. However, NMFS noted that additional data are needed to better define fish flow needs in the mainstem Willamette. This measure gives the Services approval authority over any proposed changes in the flow objectives. In the event that the RM&E studies required by measure 9 in section 9.9 indicate that different flow objectives should be established, the Action Agencies and NMFS would work together to identify flow objectives that protect ESA-listed fish species and their critical habitats.

Table 9.2-1 Mainstem Willamette Flow Objectives for "Adequate" & "Abundant" Years.[1]

TIME PERIOD	7-DAY MOVING AVERAGE [2] MINIMUM FLOW AT SALEM (CFS) USGS 14191000[4]	INSTANTANEOUS MINIMUM FLOW AT SALEM (CFS) USGS 14191000	MINIMUM FLOW AT ALBANY (CFS) [3] USGS 14174000[5]
April 1 - 30	17,800	14,300	---
May 1 - 31	15,000	12,000	---
June 1 - 15	13,000	10,500	4,500 [3]
June 16 - 30	8,700	7,000	4,500 [3]
July 1 - 31	---	6,000 [3]	4,500 [3]
August 1 - 15	---	6,000 [3]	5,000 [3]
August 16 - 31	---	6,500 [3]	5,000 [3]
September 1 - 30	---	7,000 [3]	5,000 [3]
October 1 - 31	---	7,000	5,000

[1] Appendix D defines "Adequate" and "Abundant" water years, and also describes how flow objectives can be decreased in "Deficit" water years.
[2] An average of the mean daily flows in cubic feet per second (cfs) observed over the prior 7-day period.
[3] Congressionally authorized minimum flows (House Document 531). September flows were extended into October.
[4] USGS gage 14191000 Willamette River at Salem, OR
[5] USGS gage 14174000 Willamette River at Albany, OR

2.4 **<u>Tributary Flow Objectives –Project Release Minimums:</u> The USACE will operate Willamette project dams as described in this subsection to meet or exceed minimum tributary flow objectives listed in Table 9.2-2 to ensure adult fish access to existing spawning habitat below USACE dams, protect eggs deposited during spawning, and provide juvenile rearing and adult holding habitat for listed salmonids and other fishes within system constraints described in Appendix D. If, during annual operations, the system of Willamette Projects is unable to meet both mainstem and tributary flow objectives, the Action Agencies will notify NMFS and will coordinate through WATER to determine a suitable course of action to protect priority fish habitat needs. Consistent with Appendix D, USACE will operate to meet interim draft limits.**

Rationale/Effect of RPA 2.4: This measure is based on a similar action described in section 3.3.6 of the Supplemental BA (USACE 2007a). The minimum and maximum tributary flow objectives are the same as in the Proposed Action. NMFS also recognizes that it will not be possible to meet these flow objectives under all hydrologic conditions.

However, NMFS does not agree with the Action Agencies that other project purposes (i.e. recreation), as expressed by the proposed drafting priority (Table 2-6, in Chapter 2), should take priority over meeting tributary and mainstem flow objectives. For this reason, we include RPA measure 2.4.4 to identify opportunities to manage available water resources in a manner that improves the likelihood of providing flows known to be protective of salmon and steelhead and their critical habitats (see Section 5.5.2.1). The primary difference from the Proposed Action measure is that this measure emphasizes the fisheries objectives for these flows. This measure also requires the Action Agencies to notify NMFS when they are unable to meet both mainstem and tributary flow objectives, and emphasizes that NMFS will provide guidance on fish protection priorities.

The effect of this measure is that it will better ensure adequate flows for UWR Chinook salmon and UWR steelhead that migrate and rear in Project-affected tributaries (Middle Fork Willamette, McKenzie, South Santiam, and North Santiam subbasins) than provided by the Proposed Action. In the various Effects sections for these subbasins (sections 5.2 through 5.6), NMFS found that the proposed tributary flow objectives were sufficient based on existing data. However, NMFS noted that flows released from Project dams for fish protection purposes should be protected throughout the tributary reaches where such flows are needed for spawning, rearing, holding or migration. The Proposed Action limits the Action Agencies' obligation to flow rates at the lowermost Project dam on each tributary, but does not establish flow requirements for reaches downstream from the dams to the mouth of the tributaries because the Action Agencies do not have enforcement authority over water diversions. NMFS adds sub-measures 2.4.1 through 2.4.4 below to address this issue for the lower tributary reaches. Studies required by RPA measure 2.10 below will guide decisions to modify these flow objectives to better protect ESA-listed fish species.

Table 9.2-2 Minimum & Maximum Tributary Flow Objectives below Willamette Dams (USACE 2007a; Donner 2008)

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
Hills Creek	Sep 1 - Jan 31	Migration & rearing	400	99.9		
	Feb 1 - Aug 31	Rearing	400	99.9		
Fall Creek	Sep 1 - Oct 15	Chinook spawning	200	95	400 through Sep 30, when possible	25
	Oct 16 - Jan 31	Chinook incubation	50 [3]	99.9		
	Feb 1 - Mar 31	Rearing	50	99.9		
	Apr 1 - May 31	Rearing	80	99.9		
	Jun 1 - Jun 30	Rearing/adult migration	80	99.9		
	Jul 1 - Aug 31	Rearing	80	95		
Dexter	Sep 1 - Oct 15	Chinook spawning	1200	99.9	3,500 through Sep 30, when possible	10

DAM	PERIOD	PRIMARY USE	MINIMUM FLOW (CFS) [1]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]	MAXIMUM FLOW (CFS) [2]	PERCENT OF TIME FLOW IS EQUALED OR EXCEEDED[4]
	Oct 16 - Jan 31	Chinook incubation	1200 [3]	99.9		
	Feb 1 - June 30	Rearing	1200	99.9		
	Jul 1 - Aug 31	Rearing	1200	99.9		
Big Cliff	Sep 1 - Oct 15	Chinook spawning	1500	95	3,000 through Sep 30, when possible	5
	Oct 16 - Jan 31	Chinook incubation	1200 [3]	98		
	Feb 1 - Mar 15	Rearing/adult migration	1000	99.9		
	Mar 16 - May	Steelhead spawning	1500	99.9	3,000	25
	Jun 1 – Jul 15	Steelhead incubation	1200 [3]	99.9		
	Jul 16 - Aug 31	Rearing	1000	99.9		
Foster	Sep 1 - Oct 15	Chinook spawning	1500	75	3,000 through Sep 30, when possible	1
	Oct 16 - Jan 31	Chinook incubation	1100 [3]	80		
	Feb 1 - Mar 15	Rearing	800	95		
	Mar 16 - May	Steelhead spawning	1500	80	3,000	30
	May 16 - Jun 30	Steelhead incubation	1100 [3]	95		
	Jul 1 - Aug 31	Rearing	800	99		
Blue River	Sep 1 - Oct 15	Chinook spawning	50	99.9		
	Oct 16 - Jan 31	Chinook incubation	50	99.9		
	Feb 1 - Aug 31	Rearing	50	99.9		
Cougar	Sep 1 - Oct 15	Chinook spawning	300	99.9	580 through Sep 30, when possible	60
	Oct 16 - Jan 31	Chinook incubation	300	99.9		
	Feb 1 - May 31	Rearing	300	99.9		
	Jun 1 - Jun 30	Rearing/adult migration	400	99.9		
	Jul 1 - Jul 31	Rearing	300	99.9		
	Aug 1 - Aug 31	Rearing	300	99.9		

[1] When a reservoir is at or below minimum conservation pool elevation, the minimum outflow will equal inflow or the congressionally authorized minimum flows, whichever is higher.

[2] Maximum flows are intended to minimize the potential for spawning to occur in stream areas that might subsequently be dewatered at the specified minimum flow during incubation.

[3] The USACE will attempt to avoid prolonged releases in excess of the recommended maximum spawning season discharge to avoid spawning in areas that would require high incubation flows that would be difficult to achieve and maintain throughout the incubation period. When maximum flow objectives are exceeded for a period of 72 hours or longer, the WATER Flow Management Committee will review available monitoring information (e.g., regarding redd deposition in relation to flow rates), projected runoff, and reservoir storage, and will formulate a recommendation for an appropriate and sustainable incubation flow rate prior to the initiation of the subsequent incubation period.

[4] Flow duration estimates are based on HEC-ResSim model output data for the Biop operation. Period of Record of model data is Water Years 1936-2004.

In order to improve the likelihood of meeting tributary minimum flow objectives, the Action Agencies will complete the following actions:

2.4.1 **<u>Lower River Gages</u>: The USACE will establish and operate gage stations at locations near the mouths of the tributaries listed below in this paragraph, by July 1, 2009, and will operate the stations through the term of this Opinion to develop relationships between release flows and gage flows. The plan will initially assess the adequacy of existing gages, if any, and need for new gages where none exist, in the lower reaches of the**

- **North Santiam River**
- **South Santiam River**
- **McKenzie River**
- **Middle Fork Willamette River below Dexter**
- **Middle Fork Willamette River below Hills Creek, and**
- **Fall Creek**

The need for each gage will be determined based on fish use of lower river habitat and number of consumptive water diversions in each tributary. The USACE will complete a plan identifying the number and specific location of existing and new gages that are needed, in coordination with and review by the Services,[4] by January 1, 2009. At a minimum, river stage and water temperature will be measured at those sites where gages are needed. Stage-flow relationships will be developed and maintained for accuracy. Unless good cause is given, USACE will work with U.S. Geological Survey to ensure that these stations will be part of the USGS' water data program and maintained in USGS' Real-Time data system.

Rationale/Effect of RPA 2.4.1: This measure is not in the Proposed Action. NMFS includes it here as a first step in determining whether flows released from Project dams are available for fish habitat needs in downstream tributary reaches. Presently, minimum flow targets are set at the dam, but biologically, they are needed throughout the reach. For example, if Project release flows in a given tributary are only needed for adult fish spawning in the first mile below the dam, then it is likely that those release flows are available throughout that one mile reach. On the other hand, if Project release flows are intended to provide juvenile rearing habitat in the tributary from the dam all the way downstream to its confluence with the Willamette River, then it is possible that existing, proposed, and future consumptive water users may divert these flows, resulting in inadequate habitat for juvenile rearing (or other fish habitat needs, depending on the tributary, specific reach, and species and life stages present).

NMFS acknowledges that the Action Agencies are not authorized to enforce State water rights. However, if data obtained from stream gages indicates that flows

[4] See RPA 1.3 & 1.4 for elaboration of decision making process.

are lower than needed in specific tributary reaches, then the Action Agencies could modify flow releases at dams in those tributaries to compensate consumptive water withdrawals. (See RPA 2.4.3 and 2.4.4 for this subsequent action).

The effect of this measure is that the lower river gages will allow the Action Agencies to correlate dam releases to downstream flows, such that in the future, dam releases could be adjusted, if necessary, to ensure sufficient flows are provided to the reaches where they are needed for fish spawning, rearing, passage, and holding.

2.4.2 **Tributary Instream Flow Studies: In coordination with the Services, the Action Agencies will develop a detailed study plan by December 2008 to conduct instream flow studies in 2009 and 2010. The primary goal of these studies will be to identify the relationships between river flow rates and habitat conditions for adult passage, holding, and spawning and juvenile rearing in the following tributaries: N. Santiam, S. Santiam, Fall Creek, Middle Fork Willamette, SF McKenzie, and McKenzie (listed in priority order).**

Rationale/Effect of RPA 2.4.2: As noted above in RPA 2.4 and 2.4.1, existing tributary minimum flow objectives are based on the best available data, but that in most of the tributaries, flow requirements are based on protecting a single life stage in a specific reach, such as steelhead spawning in a few miles below a Project dam. Incomplete information exists regarding fish flow needs for other life history stages when Chinook salmon and steelhead spend time in the tributaries, such as adult holding, juvenile rearing, and adult and juvenile migration. These studies need to take place in the first few years of the Opinion's term to determine fish flow needs for all life stages that use the tributaries. This information can then be used in Project operational modeling, as described in RPA 2.4.3 below, to determine if storage water is available in Project reservoirs to release needed fish flows, or if not, how reservoir operations could be optimized to best protect salmon and steelhead. Additionally, the study information would be used with gage data from RPA 2.4.1 to determine if Project release flow objectives are adequate to meet fish flow needs in lower tributary reaches.

The effect of this measure, when considered together with RPA measures 2.4.1, 2.4.3, and 2.4.4, will be to improve flow management for fish habitat needs based on current scientific analyses.

2.4.3 **Revise Minimum Flow Objectives Table: Following completion of the studies specified in RPA measure 2.4.2 above, the USACE, in coordination with the Services, will determine if the minimum and maximum flow objectives in Table 9.2-2 are appropriate. If the studies suggest that fish protection goals can be better met with different flow levels than those specified in Table 9.2-2, then USACE, consistent with 2.4.4 below, will recommend any changes in**

flow objectives in applicable tributaries to improve benefits to listed fish while continuing to meet Project purposes. The Services will inform the USACE whether they agree[5] with the modified flow objectives. By January 2011, the USACE will revise its annual water management plan to include the revised flow objectives indicated by studies in RPA measure 2.4.2, provided these flows are acceptable to the Services and that the flows can be released from Project reservoirs within existing system constraints. By January 2011, the USACE will use these flow objectives in operating the Project to the extent possible.

Rationale/Effect of RPA 2.4.3: This measure is the logical progression from RPA measures 2.4.1 and 2.4.2, by using information collected from stream gauging and instream flow studies to revise Table 9.2-2 and the annual water management plan. NMFS recognizes, however, that the flow studies may indicate the need for flow levels that could drain reservoirs and create conflicts with other Project purposes and subsequent instream water needs. For this reason, NMFS does not expect that the Action Agencies will be able to carry out preferred fish flows throughout the basin by 2011. Instead, NMFS intends that this measure will require the Action Agencies to develop a revised plan that identifies fish flow objectives, while recognizing that these flows may not be met at all times in all hydrologic conditions.

The effect of this measure will be to provide improved flows by providing guidance for flow management for fish habitat needs.

2.4.4 <u>Modify Project Operations</u>: **Following completion of the studies specified in RPA measure 2.4.2 above and determination of revised minimum flow objectives as described in RPA measure 2.4.3 above, the USACE will complete system operational modeling and NEPA analyses, if appropriate, including consideration of all project purposes, to identify modified project operations that optimize dam operations to best meet tributary and mainstem minimum flows needed to protect fish. The USACE will conduct these analyses as high-priority element of the COP (RPA measure 4.13 below). The USACE will carry out alternatives deemed feasible, as selected by the COP analysis, by January 2012.**

Rationale/Effect of RPA 2.4.4: This measure completes the studies and management plan revisions that are required by RPA measures 2.4.1, 2.4.2, and 2.4.3. These analyses will be a high priority in the COP because the information is needed to ensure that existing flow objectives are providing the expected fish benefits and, if needed, to identify alternative operations that could more effectively achieve the same benefits. The cost of the outcomes of the analyses should not require large capital investments. The purpose of this measure is to direct the USACE to complete evaluations, such as system operational modeling

[5] See RPA 1.3 & 1.4 for elaboration of decision making process.

and NEPA analyses, if necessary, to determine how to best meet revised tributary and mainstem flow objectives for fish, consistent with authorized Project purposes, and to revise system operations accordingly. By allowing an optimization routine to operate the system without arbitrary drafting priorities (see Table 2-6, in Chapter 2), the flow objectives would be met more frequently.

The effect of this analysis is to ensure that project operations are designed to manage available water resources in a manner that best protects anadromous fish and their critical habitats. This measure may require the completion of a NEPA analysis.

2.5 **Tributary Flows –Project Release Maximums: During winter steelhead and spring Chinook salmon spawning seasons, the USACE will maintain tributary flows below the specified maximum flow objectives listed in Table 9.2-2 to the extent practical when the reservoirs are below their respective rule curves. The USACE will notify the Services when maximum flow rates are exceeded according to the protocol described in measure 2.2 above.**

Rationale/Effect of RPA 2.5: This measure is similar to a related measure in section 3.3.6 of the Supplemental BA (USACE 2007a). The only difference is that this measure makes clear that the USACE will notify the Services when maximum flow objectives are exceeded. This notification is necessary to provide NMFS the opportunity to conduct a site evaluation to assess whether the high flows are causing adverse effects to listed fish and if so, to propose emergency measures to minimize these effects.

The effect of this measure is to avoid high tributary flows during spawning seasons to prevent fish from spawning at relatively high channel elevations that would likely be dewatered later in the season when flows drop. This measure will reduce the likelihood of redd desiccation and improve egg-to-fry survival.

2.6 **Ramping Rates: When project outflows are less than those in Table 9.2-3, the USACE will restrict down-ramping (the rate at which outflows are decreased) to the hourly and daily rates listed in Table 9.2-4 to minimize stranding of juvenile fish and aquatic invertebrates and desiccation of redds. NMFS' goal is for down-ramping rates not to exceed 0.1 ft/hour during nighttime hours and 0.2 ft/hour during daytime hours. Table 9.2-4 shows the increment of flow estimated to achieve a 0.1 ft/hour nighttime and 0.2 ft/hour daytime rampdown rates for a range of outflow rates.**

2.6.1 **When system operations or equipment limits prevent USACE from meeting rampdown rates at all projects, USACE will place priority on achieving ramping rates at those projects marked in Table 9.2-4 as high priority for fish protection.**

2.6.2 **The USACE will identify mechanical, operational, or equipment modifications needed to achieve these ramping rates. The Action Agencies**

will evaluate structural modifications in the COP[6] study, where indicated, to improve their ability to meet ramping rates.

2.6.3 **During active flood damage reduction operations, the USACE may deviate from the ramping rates in Table 9.2-4. However, the USACE will comply again with these ramping rates as soon as the flood risk has abated. The USACE must follow the protocol for deviations from Table 9.2-4 described in RPA measures 2.2 and 4.3.**

2.6.4 **As noted in RPA measure 2.10 below, the Action Agencies will conduct research, monitoring and evaluation of ramping rate restrictions to determine if the Table 9.2-4 ramping rates are effectively protecting fish and macroinvertebrates from stranding and redds from dewatering. Additionally, these studies will assess the effect of higher ramping rates that are presently permitted at flows greater than those in Table 9.2-3, to determine if these higher ramping rates are causing harm to ESA-listed fish or the critical habitat on which they depend. The Action Agencies will recommend appropriate changes to applicable ramping rates in Table 9.2-4 if indicated by results of the studies and consistent with authorized Project purposes. The Services will inform the Action Agencies whether they agree[7] with the modified ramping rates. The Action Agencies will implement modified ramping rates as soon as studies are completed, but no later than January 2011.**

Table 9.2-3 Project outflow rates: below these rates, down-ramping limits in Table 9.2-4 apply.

PROJECT	PROJECT OUTFLOW (CFS)
Hills Creek	1500
Dexter	3000
Fall Creek	700
Dorena	1000
Cottage Grove	800
Cougar	1200
Blue River	700
Fern Ridge	300
Foster	2000
Detroit	2000

[6] (C)onfigurations (O)peration (P)lan is Action Agencies' study and feasibility process described in section 9.4.
[7] See RPA 1.3 & 1.4 for elaboration of decision making process.

Table 9.2-4 Maximum Ramping Rates During Flow Level Changes below Upper Willamette Basin Dams (cfs)

Nighttime Rampdown Rates to Achieve 0.1 ft/hour [1, 2, 4, 5, 6]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	60[3]	1500	125	100	20[3]	100		300	30[3]	500	80[3]	250	30[3]	80	20[3]	900	100	1200	100
1000	75[3]	2000	145	300	40[3]	500	50[3]	500	40[3]	1200	100[3]	500	50[3]	150	30[3]	1900	150	1500	110
1500	90[3]	2500	150	500	50	1000	60[3]	800	50	2400	150	700	60[3]	300	40	2000	155	2000	130
1700	100	3000	170	700	60	3700	100					2300	100	1000	50				

Highlighted flows are higher than the minimum flows needed to protect ESA species, but are included to represent the lowest flow rate at which 0.1 ft/hr ramp rate is currently possible at these dams.

Daytime Rampdown Rates to Achieve 0.2 ft/hour [1, 2, 4, 5, 6]

HCR[5]		LOP[5]		FAL[5]		DOR		COT		CGR[5]		BLU[5]		FRN		FOS[5]		DET[5]	
Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change	Q	Flow diff for 0.1' change
400		1200		50				50		400		50		30		800		1000	
600	120	1500	250	100	40[3]	100		300	60	500	160	250	60[3]	80	40	900	200	1200	200
1000	150	2000	290	300	80	500	100	500	80	1200	200	500	100	150	60	1900	300	1500	220
1500	180	2500	300	500	100	1000	120	800	100			700	120	300	80	2000	310	2000	260
		3000	340	700	120									1000	100				

[1] Avoid a flow volume reduction of more than 50% per hour or the lesser of 1 foot or 50% per 24 hours. Ramping listed are decrements in release that approximately yield the resulting change in flow of 0.1 foot/hour or 0.2 foot/hour.
[2] Operations prevent USACE from meeting rampdown rates at all projects, USACE will place priority on achieving ramp rates at these projects noted as high priority for fish protection.
[3] USACE cannot achieve ramping rates at low flows due to adjustment limits of existing equipment.
[4] NMFS prefers using 0.1 ft/hour during all hours from January 1 through March 31 because mostly fry-aged fish are present then and are less able to avoid ramping effects.
[5] High priority because of the presence of ESA listed salmon and steelhead. Rates listed are for reservoir operation other than when reducing project outflow to manage for downstream flood damage reduction.
[6] Change in flow at flows higher than those listed are less critical for protecting ESA species because of proportionally smaller flow volume change.

Rationale/Effect of RPA 2.6: The objective of this measure is to minimize project effects of entrapment and stranding of juvenile salmon and steelhead in Project-affected tributaries, and to minimize the adverse effects of Project-caused discharge fluctuations on stream biota. Unregulated rivers rarely have drops in stage in excess of two inches per hour (except during floods) whereas regulated rivers can have greater and more frequent stage changes. Thus, aquatic life is not well adapted to stage drops in excess of one or two inches per hour. Fish stranding is one of the greatest negative impacts of excessive stage change. The incidence of stranding is affected by fish size, species, time of day, substrate type, channel contour, magnitude of flow change, and rate of flow change (Hunter 1992). Redd dewatering, reduced invertebrate productivity, fish emigration, and exclusion from spawning habitat can also occur. These are all adverse effects to critical habitat as well as to population numbers.

Measure 2.6.1 recognizes that equipment limits at some of the dams prevents the USACE from making fine adjustments to reservoir discharge, particularly at very low flows. This limits their ability to guarantee that they will meet ramping rate limits specified in Table 9.2-4 at all times. Despite these restrictions, the Action Agencies will to make every effort to meet the Table 9.2-4 ramping rates within existing equipment restrictions, as stated in the Proposed Action.

NMFS includes Measure 2.6.2 to require the Action Agencies to identify modifications that could be made to existing equipment and operations to enable them to meet Table 9.2-4 ramping rates at low flows. The list of modifications should be evaluated in the COP study to identify priorities for making such changes and to seek funding for this work.

Measure 2.6.3 is necessary because during high flow periods, the risk of floods increases, and the Action Agencies need more flexibility to quickly modify reservoir discharges to minimize flood risk. This extra flexibility will not harm UWR Chinook salmon and UWR steelhead because down-ramping at high flows is less likely to cause fish to strand and redds to be dewatered than downramping at lower flows. This reduced impact results from the general relationship that at high flows, large decreases in flows can result in relatively small changes in water depth, while at low flows, a change in flow can result in relatively large changes in water depth, increasing the risk of fish stranding. During flood damage reduction operations, the USACE will attempt to meet the Table 9.2-4 ramp rates, but will not be required to meet these rates.

Measure 2.6.4 references flow-related RM&E actions that are necessary as part of the RPA and Proposed Action. Project-specific ramping rate studies have not been done at Willamette Project dams, and the extent of stranding over a range of ramping rates has not been determined. These RM&Es are needed to assess whether the Table 9.2-4 ramping rates are effectively preventing fish stranding and other harm to stream biota, as well as to determine if assumptions regarding reduced risk at higher flow levels and during flood operations are valid. This measure includes a process that the Action Agencies will use to modify ramping rates and flows at which they apply, if indicated by study results.

The effect of measure 2.6 and its subcategories, 2.6.1 through 2.6.4 is that these measures will minimize entrapment and stranding of UWR Chinook salmon and UWR steelhead juvenile fish and dewatering of their redds in Project-affected tributaries and will minimize the adverse effects of Project-caused discharge fluctuations on stream biota and critical habitat. Actions will be taken to correct existing equipment that prevents the Action Agencies from meeting Table 9.2-4 ramping rates at very low flows, and studies will evaluate the effectiveness of these ramping rates and may identify revised rates that will further reduce fish entrapment and stranding. Structural modifications and changes to ramping rates will be considered and carried out where feasible and necessary to minimize adverse effects on ESA-listed fish.

2.7 **Environmental Flow[8]/Pulse Flow Components: The Action Agencies will work through the WATER Flow Management Committee and with the Services, and other aquatic scientists with expertise in Willamette basin fish ecology and fluvial geomorphology, and stakeholders, to identify environmental flow improvement opportunities for the mainstem Willamette River and the lower reaches of tributaries with USACE dams. The Action Agencies will design, test, and carry out modifications to flow releases from USACE dams to improve channel morphology in a manner that would create and sustain new, and improve existing, fish habitat through changes in project operations, while still addressing other authorized Project purposes. For each tributary, the process will begin by identifying fluvial morphology components[9] important to ESA-listed salmonids and other biota that are currently underrepresented in the watershed. Following identification of these morphological conditions, the Action Agencies will examine the potential for improving these conditions through modification of project operations, as the Sustainable Rivers Project has done for the Middle Fork Willamette River in an effort summarized by Gregory et al. (2007). The Action Agencies will identify weak or missing morphological characteristics and, where feasible, will incorporate remedies to these conditions into one or more flow modification proposals. The Action Agencies will then submit proposals to the Flow Management Committee of WATER, which will recommend adjustments, if appropriate. The Services will inform the Action Agencies if they agree with the proposals. The Action Agencies will then carry out these flow modification proposals, initially as pilot studies and then, if determined feasible, as part of its regular water management operations. The Action Agencies will monitor the effectiveness of each environmental flow operation at achieving specific ecological objectives beneficial to ESA-listed**

[8] "Environmental flows" are used in this context to refer to a full range of pulses or high flows that accomplish various fish habitat maintenance and creation through mechanisms such as sediment distribution, channel forming processes, overbank flows, maintaining access to side or off-channel habitat.
[9] Such components may include appropriate seasons, magnitudes, durations, or rates of change in specific components of the annual hydrograph, including fall transition flows, small fall pulses in flow, winter bankfull flow pulses, small or larger floods above bankfull river levels, spring pulse flows, spring-to-summer transitions in flow, and summer baseflows.

salmonids and/or other aquatic biota. The Action Agencies will complete appropriate NEPA evaluation for alternatives being considered

Flow changes that may result from this measure could fall into one of three implementation types: (1) flow volume and timing adjustments that are within the operational flexibility of the USACE under current project authorizations and water control manuals; (2) larger scale adjustments that may fall within current operational flexibility and authority but whose implementation requires detailed evaluation of tradeoffs; and (3) major changes in operation which are clearly outside of the USACE's operational discretion and would require a thorough feasibility evaluation and possible reauthorization action. The USACE will begin implementing proposals for Type 1 environmental flow modifications on the lower Middle Fork Willamette, below Dexter Dam, in FY 2009, and explore with the Services and the Flow Management Committee of WATER any needs and opportunities to implement Type 2 or 3 flow modifications there in subsequent years. The Action Agencies will develop and carry out proposals for environmental flow modifications below other USACE dams in the Willamette Basin during the term of this Biological Opinion, with priorities among rivers identified by the Flow Management Committee. Within this period, a full effort will be made to optimize USACE management of flows in the tributaries and mainstem so as to achieve improved fish habitat benefits that are not incompatible with other purposes of the dams.

Rationale/Effect of RPA 2.7: Natural patterns of variation in flow exert significant influence on the habitat and ecology of UWR Chinook, UWR steelhead, and other aquatic organisms native to the Willamette Basin. Flow alteration by the system of USACE dams in the Willamette Basin has contributed to profound changes in the freshwater habitat of UWR Chinook and UWR steelhead. Requirements elsewhere in this Biological Opinion for seasonal minimums and maximums in flow, and for limits on down-ramp rates, do not fully address historical changes to natural patterns of variation in flow or to channel forming flows that may at present constrain the abundance and productivity of these ESA-listed anadromous fish.

The effect of this measure is to initially make minor improvements to existing spawning and juvenile rearing habitat downstream of Dexter Dam in the Middle Fork Willamette and below Dorena and Cottage Grove in the Coast Fork Willamette River. As the Action Agencies begin to release Type 1 flow modifications in other Project-affected subbasins, there will also be minor improvements to existing spawning and juvenile rearing habitat due to increased flushing of sediments, cleaning out small particles and moving new gravels into usable habitat. Over the next 15 years, Type 2 and possibly Type 3 flow modifications that will be carried out in the Middle Fork Willamette and at Project dams in other subbasins will improve or create and sustain new juvenile rearing habitat in complex habitat, side channels, or other morphological features. These actions will increase available rearing habitat and make existing spawning and rearing habitat below Project dams more suitable, resulting in increased productivity and abundance. Adverse effects on critical habitat in reaches below dams will be reduced because this measure will improve existing rearing and spawning habitat and may create and maintain new rearing habitat.

2.8 Foster Spring Spill: The USACE will continue to spill at Foster Dam between 0.5 and 1.5 feet of water (approximately 92 to 238 cfs), depending upon inflow and forebay elevation fluctuations, over the spillway fish weir[10]. This operation will occur from 0600 through 2100 hours daily during the primary fish passage season, April 15 through May 15. The Action Agencies will evaluate the effectiveness of this operation on downstream fish passage as part of RM&E (RPA measure 2.10) and COP studies (RPA measure 4.13). Based on the results of these studies, the Action Agencies will recommend modifications to this spill operation or new downstream fish passage facilities or operations. If modified operations are warranted and can be carried out within existing physical and operational constraints, the Action Agencies will begin to carry out these operations consistent with RPA measure 4.8, Interim Downstream Fish Passage. If more extensive modifications are needed, the Action Agencies will follow the process described in the COP study, RPA measure 4.13.

Rationale/Effect of RPA 2.8: This measure would continue an existing spill program that provides better downstream juvenile steelhead passage survival than turbine passage at Foster Dam (see South Santiam Baseline section 4.5.3.1). Although based on a similar action described in section 3.3.8 of the Supplemental BA (USACE 2007a), NMFS includes a requirement that this measure be evaluated as part of the RM&E (RPA measure 2.10) and COP studies (RPA measure 4.13), and that the Action Agencies will modify this measure if indicated by study results.

The effect of this spill operation will be improved survival of juvenile steelhead, and likely Chinook salmon, emigrating from above Foster Dam as a result of the outplanting program.

2.9 Protecting Stored Water Released for Fish: In coordination with the OWRD and ODFW, the Action Agencies will facilitate conversion of stored water to an instream flow water right. Oregon adopted minimum perennial streamflows for Willamette tributaries in Oregon's Willamette Basin Program (Table 1 in ORS 690-502). After being converted to water rights under Oregon law, OWRD can protect the minimum perennial stream flows from illegal diversion. The State of Oregon is solely responsible for administering and enforcing state water rights.

Additionally, the Action Agencies will identify stored water in addition to the minimum perennial streamflows that could be allocated from reservoirs to enhance salmon and steelhead survival. The Action Agencies will proceed with necessary actions to allocate and protect water for this purpose. In particular, USACE and

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[10] To provide a measure of downstream fish passage, Foster dam employs an overflow weir immediately upstream of one tainter gate (which is raised, out of service, when the fish weir is employed). This fish weir provides a surface oriented flow that better attracts and conveys fish than turbine flow.

Reclamation will coordinate with OWRD on several tasks to accomplish this measure: 1) identify current water storage at USACE reservoirs that could be allocated to instream flow for ESA listed fish; 2) determine how to legally transfer flow for instream purposes; and 3) proceed with the necessary analyses to implement the agreed upon transfers. The tasks necessary to accomplish this action may require approval from Congress. This effort will begin immediately. By the end of 2009, the Action Agencies will have coordinated with all appropriate agencies and determined the path forward in order to accomplish this action.

Rationale/Effect of RPA 2.9: Water use and development in the Willamette basin are expected to continue to grow, making it very important to preserve adequate water for fish, particularly in the tributaries. Although the Action Agencies have agreed to release minimum flows from Project dams to support fish life in tributary reaches, they cannot guarantee that these flows will be maintained throughout the reach because the State (OWRD), not the Action Agencies, has enforcement authority over water rights. Current Oregon water law allows holders of natural flow water rights in the Willamette basin to divert stored water released from Project dams when this water is not obligated by existing Reclamation contracts. Thus, even though the Action Agencies intend for some of the stored water that is released to provide fish benefits, OWRD is not authorized to protect these flows from diversion by water users because this water is not currently obligated by a contract. In early 2008, NMFS participated in staff-level meetings with OWRD, Reclamation, BPA, and USACE to identify available mechanisms for protecting these minimum flow releases for fish purposes. As a result of these meetings, the Action Agencies agreed to investigate and carry out steps to achieve this purpose of protecting a certain amount of stream flows for fish. The exact steps that the Action Agencies will take have yet to be determined, but they must first request from OWRD a transfer of portions of the existing irrigation storage water rights to another use, such as multi-purpose or fish protection.

The effect of this measure is that the flows released from Project dams for fish protection purposes will remain instream and provide intended biological benefits. Although the Action Agencies cannot guarantee what action the State of Oregon may take, this measure requires the Action Agencies to take steps within their authorities to protect these flows.

2.10 **<u>Flow Related Research, Monitoring and Evaluation</u>: As part of the RM&E plan described in RPA measure 9 below, the Action Agencies will plan and carry out studies and monitoring of mainstem and tributary flow rates and Project ramping rate restrictions necessary to protect fish and aquatic habitat, as well as other evaluations required by measures in this section. The flow and ramping rate studies will be considered high priority and field studies should begin in 2009, with initial results available to inform modified flows and ramping rates by January 2011.**

Rationale/Effect of RPA 2.10: This measure is needed to evaluate the effectiveness of mainstem and tributary flows, ramping rate restrictions, and other flow-related measures such as Foster Spring Spill (RPA measure 2.8). Flow and ramping rate evaluations are high priority studies because they will provide the information necessary to identify any necessary changes in project operations to protect UWR Chinook salmon and UWR steelhead. If studies indicate that different flows or ramping rates would be more effective at protecting fish, then the Action Agencies could carry out such changes as quickly as possible to ensure fish protection during this interim period.

The effect of this measure is that study results will be used to modify project operations and flows to improve UWR Chinook salmon and UWR steelhead survival in the tributaries below Project dams and in the mainstem Willamette River. Life stages affected will be fry and juveniles from stranding, smolting juveniles during migration, adults during migration and holding, and eggs in redds from dewatering associated with Project ramping.

9.3 WATER CONTRACT PROGRAM

One of the authorized purposes of the Willamette Project is the distribution of stored water to users who have contracts with Reclamation for irrigation use. As described in Effects Section 5.1, diversion of water to serve these contracts can adversely affect UWR Chinook and UWR steelhead by reducing the amount of stream flow available for use by all life stages and by entraining juveniles into water diversions. These RPA measures are intended to minimize the effects of diverting water served by Reclamation contracts on listed species by limiting the volume of new contracts that can be issued, requiring existing contract diversions to install screens and other fish passage devices within specified timeframe, requiring screening of all new contract diversions, ensuring that water released to serve contracts does not diminish water available to meet minimum flow objectives, and reducing the volume of stored water diverted to contract holders in low water years to ensure minimum objectives are met. These measures will also minimize destruction and adverse modification of critical habitat due to water diversions because they limit the total amount of water that can be diverted and require fish protection measures at the diversions.

RPA 3   Bureau of Reclamation Water Contract Program

Reclamation and the USACE will continue the existing irrigation contract water marketing program for the Willamette Project. Reclamation will issue new contracts, except as specified in RPA measure 3.1 below regarding new contracts in the N. and S. Santiam subbasins, and provided that the total water marketing program, including existing contracts, does not exceed a total of 95,000 acre feet. In the event that future irrigation demand exceeds 95,000 acre-feet, Reclamation and the USACE will reevaluate the availability of water from conservation storage for the water marketing program and reinitiate consultation with the Services if they propose to issue additional contracts.

In addition, all contracts will be subject to the availability of water, as determined by USACE. Therefore water may not be available for some or all of each year in order to meet ESA requirements and other project obligations for instream flows (e.g. minimum flows to protect water quality). Reclamation

may issue notices, orders, rules, or regulations governing water service as necessary to comply with the requirements of the ESA, including appropriate biological opinions and Incidental Take Statements.

Rationale/Effect of RPA 3: This measure builds on a similar action described in section 3.9 of the Supplemental BA (USACE 2007a). NMFS describes the effects of the Action Agencies' Proposed Action in the General Effects Section 5.1. In that section, NMFS finds that in most years and in most of the Project-affected tributaries, sufficient water is available to meet fish flow needs and still supply a water marketing program of up to 95,000 acre-feet and that Reclamation's contract language affords it the ability to curtail irrigation water deliveries when insufficient water is available to meet both instream flow needs and irrigation demand. (Measure 3.1 addresses NMFS' finding that there is insufficient water available to meet both fish flow and contract needs in the North Santiam and South Santiam rivers in most years). This measure specifies that as new contracts are issued and existing ones are renewed, Reclamation must make sure that the total amount of contracted water stays at or below 95,000 acre-feet. If future demand is for more than the existing total, then Reclamation and USACE must reinitiate consultation prior to issuing contracts that would exceed the 95,000-acre-foot limit.

The effect of this measure is to ensure that adequate water is available for possible use for protection of listed fish in the tributaries and mainstem Willamette. This measure also minimizes adverse effects on critical habitat by providing enough water so that minimum flows needed for properly functioning habitat are not precluded by the contract program.

3.1 **<u>New Contract Issuance</u>: Reclamation will not issue irrigation water service contracts in the North Santiam River and the South Santiam River that would in total exceed the current total of 11,574 ac ft (85 cfs) and 1,096 ac ft (7 cfs) respectively.**

The USACE will update its flow exceedance models (similar to Appendix C of the Supplemental BA; USACE 2007a) every five years, and, together with results of fish flow studies, determine whether additional water is available during most years for new irrigation contracts based on this information. If, based on these analyses and other information, the USACE determines that additional water is available to serve irrigation demand (beyond the volumes specified above) without adversely affecting listed fish and their critical habitats, then the USACE will inform Reclamation and seek the written agreement of the Services. The Services will inform the USACE in writing whether they agree[11] with the USACE's determination. If the result of this process is an affirmative determination that additional water is available, Reclamation may issue new contracts based on and limited by the USACE's determination.

Rationale/Effect of RPA 3.1*:* NMFS includes this measure to prevent further reductions in streamflow in the North and South Santiam rivers until and unless a showing is made

[11] See RPA 1.3 & 1.4 for elaboration of decision making process.

that additional water is available. The North and Santiam rivers are core population areas for UWR Chinook and UWR steelhead. As described in RPA 2.4, tributary minimum flows are needed to provide adequate rearing, spawning, holding and migration habitat for UWR Chinook salmon and UWR steelhead. Analysis conducted by the USACE and summarized in tables 5.5-2 (South Santiam Effects section) and 5.6-1 (North Santiam Effects section) indicates that minimum tributary flows are not met during certain months of the year. In the South Santiam, USACE estimates a 25% chance of not meeting the 1500 cfs minimum flow for Chinook spawning from September 1 through October 15, a 20% chance of not meeting the 1100 cfs Chinook incubation flows from October 16 through January 31, and a 20% chance of not meeting the 1500 cfs steelhead spawning flows from March 16 through May 15. In the North Santiam, Chinook spawning flows of 1500 cfs are not likely to be met about 5% of the time.

Additionally, as described in the North Santiam Effects section 5.6.2.1 and in RPA measure 2.4 (tributary minimum flows), the Action Agencies release minimum flows at the dams, but have no authority to enforce these minimums through tributary reaches. In the North Santiam, although the chance of not meeting summer rearing flows of 1000 from July 16 through August 31 is less than or equal to 1% at Big Cliff Dam, the likelihood that this flow will be sustained through the reach downstream to the confluence with the South Santiam is low. OWRD has issued water rights for up to 2,730 cfs from the N. Santiam River between Big Cliff Dam and the South Santiam confluence (about half of which is used for hydroelectric power and affects a short stretch of river). While total diversions seldom if ever reach this total permitted amount, diminished flows have been identified as a limiting factor for UWR Chinook and UWR steelhead in the basin.

Based on this information, it is clear that permitting additional water to be diverted from the stream would further reduce the likelihood of meeting minimum flows and result in less habitat available for rearing, spawning, and incubation. Because OWRD has determined that natural flow is unavailable in the North Santiam River, this curtailment of further water service contract issuance effectively protects the river from further flow reduction.

The effect of this measure is that streamflow in the North and South Santiam rivers would not be further reduced by diversions permitted with new Reclamation contracts. This measure would not improve fish habitat, but it would prevent further degradation. The amount of rearing habitat available to juvenile UWR Chinook and steelhead would continue to be reduced from points of diversion serviced by contracts to the confluence of the mainstem Santiam River with the Willamette during July and August of each year.

3.2 **Existing Contracts: All existing contracted diversions will be required, as a condition of continuing to receive project water, to have fish protection devices that comply with NMFS design criteria, and are approved by NMFS.[12] While this clause is primarily about fish screens, it is not limited to fish screening. Based on the**

[12] Projects that have had, within the last 15 years, site-specific ESA Section 7 consultations performed with respect to fish protection devices are deemed compliant.

effect of the diversion on anadromous fish, fish protection devices could include upstream passage at dams, exclusion of fish from irrigation water return channels, and other fish hazards presented by water diversion practices. Contractors that do not comply with Reclamation's notice or otherwise fail to obtain certification by NMFS as having adequate fish protection devices will not be eligible to continue to receive irrigation water service from the Project and their contract may be subject to termination. The compliance deadline is April 1, 2010, unless a later date is authorized by NMFS.[13]

1. **By October 1, 2008, Reclamation will send written notification to all existing contractors notifying them that in order for them to continue receiving irrigation water service from the Project, their diversions must have fish protection devices that comply with current NMFS fish protection requirements,[14] and are approved by NMFS. Contractors will be required to request assessment by entities listed in the Bureau's written notification letter. Within the time frame specified by Reclamation in its notice, contractors will be required to provide Reclamation with written assessment[15] that their diversions conform to NMFS criteria. Reclamation will assemble this information and provide it to NMFS. NMFS will then make a determination as to whether NMFS agrees that the fish protection measures are sufficient to protect ESA-listed fish, and will advise the water user and Reclamation of this determination. NMFS may ask for additional information, or may need to visit the diversions in order to make its determination. If NMFS requests a site visit, NMFS will inform Reclamation.[16]**
2. **While contractors proceed with the fish protection device installation or modification and approval process, they may continue to divert water under the terms and conditions of their existing contracts, as long as they meet the deadline provided to them by Reclamation.**
3. **As another condition of receiving water, every five to seven years, contractors must re-confirm that their diversions are still in conformance with NMFS design guidelines.**

Rationale/Effect of RPA 3.2: This measure requires screening or other appropriate fish passage devices at diversions with existing Reclamation contracts that will not be renewed for a number of years. In most cases, fish entrainment into a diversion is lethal. Measure 3.3 below ensures that these protections will be required at renewal, but does not require immediate screening of all existing diversions.

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[13] Reasons for extending this date might include challenging design requirements, or atypically large and complicated projects.
[14] See Anadromous Salmonid Passage Facility Design, National Marine Fisheries Service, Northwest Region, February 2008, NMFS 2008e
[15] NMFS will accept assessments by ODFW, Reclamation, or others, based on a Memoranda of Understanding between these Agencies and NMFS with respect to technical acceptance criteria.
[16] Initially, all diversions will require a site inspection by NMFS; ideally, however, Reclamation and NMFS will develop a protocol to avoid site visits for every pumped, diversion, particularly small ones.

The effect of this measure is that losses of juvenile Chinook and steelhead due to entrainment or ineffective passage at existing diversions will only continue until April 1, 2010.

3.3 <u>New & Renewed Contracts – Conditions</u>: **Reclamation will require renewed and new contracts to meet all of the following:**

1. **Compliance with NMFS fish protection criteria, as required for existing diversions in 3.2, above.**
2. **Surface water diversions must have lockable headgates that are capable of easily starting, adjusting and stopping[17] the flow of water.[18]**
3. **Diversions greater than 3 cfs must have devices to enable measurement of the instantaneous rate of water delivery, within 5% accuracy.[19] Diversions over 10 cfs must also have a flow totalizer that calculates total volume of water diverted.**
4. **Reclamation will include provisions to curtail or cease entirely all water deliveries in specific areas, if certain flows are necessary to protect listed species and their critical habitats.**

Rationale/Effect of RPA 3.3: This measure is included to ensure that new and renewed contracts include conditions to protect fish from entrainment into diversions and to ensure that rate and volume of water diverted can be easily and accurately controlled. In most cases, fish entrainment into a diversion is lethal. The OWRD now requires new surface water right permittees in the Willamette basin to screen their diversions to avoid entrainment; however, an unknown number of diversions using older federal water service contracts are unscreened.

This effect of this measure is to minimize loss of UWR Chinook salmon and steelhead at diversions that acquire a new or renewed Reclamation contract. During the 15-year term of this Opinion, about 48 of the 205 existing contracts will be eligible for renewal. Harm will be reduced by requiring screens to be installed and operated at contract diversions. Contract conditions requiring headgate flow controls, measurement, and water curtailment will reduce adverse effects on listed fish due to reduced river flow.

3.4 <u>Annual Availability of Contract Water for Irrigation</u>: **Contract fulfillment is subject to the USACE's annual operating plan for the Willamette Basin Project in which the USACE determines availability of water for Reclamation contracts. If USACE determines that a shortage will occur, or is forecasted to occur, USACE can designate this shortage to specific tributary subbasins,**

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[17] To less than 1.0 cfs.

[18] Pumped diversions are presumed to inherently possess this capability.

[19] Any of the measurement methods described in the *Reclamation Water Measurement Manual* for measuring instantaneous flow rate shall be acceptable, but generally for surface water diversions, and pumps that discharge to canals, this will likely be a flume; for flows entirely within conduit, a pipeline flow meter is presumed. Indirect methods based upon pump(s) electrical power consumption require field calibration (USBR 2001a) and an engineer's certification of the correlation between electrical power consumption and flow.

certain reaches, or throughout the Willamette basin, limiting the availability of the contract water supply. Reclamation will notify contractees of storage water shortages as described below. Appendix D further describes how water years are designated and is hereby incorporated into this RPA by reference.

Each year on or before April 1, the USACE will determine availability of water for irrigation contracts based on the best information available at that time.

DEFICIT YEARS:

(a) In "deficit" water years (as defined in Appendix D), the USACE will inform Reclamation that either (1) a specified partial supply or (2) no supply is available for the upcoming irrigation season in specific tributaries and will include this determination in the annual operating plan. The April 1 determination will remain in effect until October 31. The USACE may revise its "deficit" water year determination after April 1 if forecasts change significantly toward a wet year, and may make additional stored water available to meet irrigation contracts.

(b) Reclamation will notify affected contractees that water deliveries will be ceased or curtailed under these circumstances. Reclamation may apply the curtailment or cessation of water deliveries to specific tributaries where it is needed, but not in others, depending on water availability and storage capacity in each basin's reservoirs. Reclamation will also inform the OWRD of such actions.

(c) If the USACE determines initially that a partial supply is available for contractees, but later forecasts indicate even less water is available, in order to protect fish habitat the USACE will release additional flow from the applicable dams to offset the amounts diverted by contractees, based on the partial use that had been permitted on April 1. This additional flow will not be released if, based on coordination through WATER, it is determined these additional flows would impact ability to meet Table 9.2-1 (mainstem) and 9.2-2 (tributary) minimum flows during other seasons.

INSUFFICIENT, ADEQUATE, & ABUNDANT YEARS:

(a) In these water years (as defined in Appendix D), the USACE will usually not make a determination that would curtail contractees' use of water.

(b) Instead, the USACE will release additional flow (over the Table 9.2-2 flow rates) to offset the amount of flow diverted by

contractees, as estimated in Table 3-26 of the Proposed Action (USACE 2007a) (or based on updated estimates by Reclamation of actual use). This measure does not apply to the Coast Fork or Long Tom subbasins.

(c) The schedule for when and if to begin and end additional flow releases will be annually determined through the WATER Flow Management Committee, which will consider fish flow needs, Reclamation's estimate of contract water usage, and reservoir storage available for meeting tributary and mainstem flow objectives throughout the water year.

(d) In tributaries and reaches where the sum total of existing and new contracts is less than 20 cfs or otherwise beyond adjustment capabilities at each project dam, the USACE will attempt to release these additional increments. However, downstream gage data may not detect relatively small increases in flow over Table 9.2-2 releases.

(e) The USACE will not be required to make RPA measure 2.2 deviation reports where contracted flow is less than 20 cfs; NMFS will consider requests to waive RPA measure 2.2 deviation reports in other situations, as well, on a case-by-case basis.

Rationale/Effect of RPA 3.4: Under the Proposed Action, USACE would not increase the discharge rate at individual projects to meet Reclamation contracts, reasoning that established project minimum discharge rates are sufficient to meet those needs and contract diversions take a *de minimus* volume of water. Because the tributary minimum flows established in RPA measure 2.4 are designed to protect listed fish throughout the stream reaches downstream from Project dams, diverting water under Reclamation contracts while Willamette Project dams are discharging to meet minimum flows could put listed fish at risk. This RPA measure requires Reclamation to curtail contract diversions in Deficit water years, and, in all other water years, it requires USACE to release additional water above the minimum flow levels to ensure that contract users do not take water intended for fish purposes.

As a means to reduce risk to contractors, USACE will identify the likelihood of curtailment by April 1, prior to the irrigation season through the development of the Willamette Conservation Plan. Such early notification would assist water users to plan appropriately for a water shortage. In the event that the USACE's forecast is incorrect, and a forecast that appeared adequate (not requiring any curtailments) on April 1st changes to one predicting a "deficit" water year, the USACE will release additional flow at its dams to make up for the contracted amounts. This would protect contractors from interrupted water service mid-season, when it could result in excessive crop damage, but would ensure that streamflows are not further reduced due to contract withdrawals in such flow years.

Curtailments under this measure could be for one or more individual tributaries or the entire basin and could be in force for only a few weeks or the entire irrigation season.

Innovative solutions to minimize impacts to water users, such as rotational diversion timing, may be proposed by Reclamation and OWRD and may be adopted by NMFS.

The effect of this RPA measure is that losses to listed fish species from low stream flows will be reduced while allowing the Action Agencies to continue serving other project purposes to the extent practical. Adverse effects on critical habitat will be reduced because this measure will provide for flows necessary to support listed fish.

9.4 FISH PASSAGE

The Proposed Action included studies to consider passage at Project dams, but did not include specific passage measures and time frames associated with the measures. As discussed in the Effects (Chapter 5) and Summary of Effects (Chapter 7) sections of this Opinion, for UWR Chinook salmon and UWR steelhead, lack of passage is one of the single most significant adverse effects on both the fish and their habitat. In its jeopardy and destruction and adverse modification of critical habitat analyses, NMFS identified the need for more specific measures with associated time frames. Specific passage measures are necessary to address the effects of the Project. Therefore, NMFS includes specific passage measures to be completed and operational by set deadlines. NMFS also includes a measure to ensure that the Action Agencies continue to work toward providing more specific passage measures, if appropriate, past the time frame of RPA.

RPA 4 Fish Passage

4.1 <u>**Adult Chinook Salmon Outplanting**</u>**: The Action Agencies will continue capturing spring Chinook salmon below USACE dams and transporting them into habitat above the following dams:**

- **Detroit Dam in the North Santiam River basin;**
- **Foster Dam in the South Santiam River basin;**
- **Cougar Dam in the South Fork McKenzie River basin;**
- **Lookout Point and Hills Creek dams in the upper Middle Fork Willamette River subbasin; and**
- **Fall Creek Dam in the Fall Creek River basin.**

Additionally, if NMFS, after coordination with the Fish Passage and Hatchery Management Committee (FPHM) of WATER, determines it is necessary to evaluate passage at Green Peter Dam, then the Action Agencies will also release Chinook salmon above that dam in the South Santiam.

The Outplant Program will provide upstream fish passage for adults via "trap and haul" facilities while USACE carries out studies to assess upstream and downstream fish passage alternatives at these dams and reservoirs (see RPA measures 4.10, 4.11, and 4.12 below). The interim operational guidelines and protocols for outplanting fish will be as described in section 3.4.5 of the Supplemental BA (USACE 2007a),

NMFS (2006f) and section 15 of each ODFW (2003, 2007a, 2008a, and 2008b).[20] The Outplant Program will be carried out consistently with the guidelines, protocols, and criteria specified in the Willamette Fish Operations Plan (see RPA measure 4.3 below) and annual revisions to this plan (see RPA measure 4.4 below). (See also RPA measure 6.2.3 below, which references this same Outplant Program as part of the hatchery-related measures).

Rationale/Effect of RPA 4.1: This measure is generally consistent with section 3.4.5.3 of the Proposed Action (USACE 2007a), in which the Action Agencies propose to continue the Outplant Program consistent with a philosophy described in detail in section 3.4.4.5 of the Proposed Action. The outplant program is a first step to provide UWR Chinook salmon and UWR steelhead access to historical habitat above Project dams, but by itself won't be sufficient. The major distinction between the PA and RPA for the outplanting program is that harm to listed fish should be decreased by following guidelines developed to minimize effects on the fish.

As described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6), the outplanting measures in the PA do not provide safe passage. Therefore, improvements in fish trapping, handling, transport, and release are needed to minimize stress and injury to adult fish. The interim guidelines and protocols, as implemented by the Action Agencies, will help to reduce fish stress and injury.

The Outplant Program, as modified based on monitoring and evaluation and with improved trapping facilities described in RPA measure 4.6, will provide adequate temporary upstream passage to ensure fish access to historical habitat. In most situations where fish passage at a dam is needed, NMFS would consider volitional passage via a fish ladder or other fishway as its first choice alternative. However, for the Willamette Project dams, in this case, sufficient improvements in upstream passage can be achieved in the short term with improved fish trap and transport facilities while efforts are focused on achieving safe downstream fish passage through the dams and reservoirs. Once downstream fish passage facilities are completed and demonstrated to provide safe and timely passage, then NMFS will reconsider whether volitional upstream passage is needed at certain Project dams.

This measure requires the Action Agencies to transport listed fish to the described locations. Fish habitat above dams was historically preferred for spawning and rearing. Since dam construction, remaining fish habitat below dams has been degraded by dam and reservoir operations, as well as other actions such as land use and agricultural and industrial water pollution. Lack of access to good habitat is considered a major reason for the decline in productivity of UWR Chinook, and most of the good habitat, and hope for restoring productivity, lies above project dams.

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[20] Hatchery and Genetic Management Plans (ODFW 2003, 2004a, 2005, 2007a, 2008a, and 2008b) are described in the salmon and steelhead 4(d) rule as a mechanism for addressing "take" of ESA-listed species that may occur as a result of artificial propagation activities.

The effect of this measure will be to require efforts to restore productivity of listed fish. Restoration of productivity is key to adequately addressing the effects of the Project because the extremely low numbers of wild fish caused by lack of or inadequate access to historical habitat are the major factor contributing to the species' decline. Lack of access to good habitat above the dams, injury and mortality associated with inadequate passage facilities, and restriction to degraded habitat below the dams has caused steep declines in numbers and has reduced the functioning of PCEs of critical habitat.

4.2 <u>Winter Steelhead Passage:</u> **The Action Agencies will continue to trap adult winter steelhead at Foster Dam in the South Santiam River and transport them to release sites above Foster reservoir. If NMFS and the Action Agencies, in coordination with the FPHM of WATER, determine it necessary for evaluation of winter steelhead passage at Green Peter Dam, then the Action Agencies will release some portion of the winter steelhead captured at the Foster Dam trap above Green Peter reservoir in the South Santiam. Additionally, if NMFS and the Action Agencies, in coordination with the FPHM, determine it necessary for evaluation of steelhead passage at Detroit and Big Cliff dams, then the Action Agencies will trap winter steelhead at the Minto Trap or other locations in the North Santiam River below Big Cliff Dam and release them above Detroit and/or Big Cliff dams, as directed by NMFS.**

Rationale/Effect of RPA 4.2: The Outplant Program described above in RPA measure 4.1, has focused on upstream passage of UWR Chinook salmon, but UWR steelhead access to historical habitat in the South and North Santiam rivers is also needed. In the South Santiam subbasin, the Action Agencies have continued to pass UWR steelhead above Foster Dam since dam construction, relying on a surface spill program to flush juvenile steelhead from the reservoir during the peak migration period. As described in Section 4.5.3 (Baseline South Santiam), upstream passage at Green Peter Dam was discontinued in 1988 because adults were not attracted to the cold water from the ladder and a low percentage of downstream migrants were collected in the downstream fish collection facility. This measure requires the Action Agencies to continue to pass UWR steelhead above Foster Dam, and possibly, above Green Peter Dam.

In the North Santiam subbasin, steelhead passage to historical habitat above Big Cliff and Detroit dams was blocked in 1953, when construction of the dams without fish passage facilities was completed (see section 4.6.3, Baseline North Santiam). As described in Effects Section 5.6, UWR steelhead spawn in the North Santiam below Big Cliff Dam. Although water quality and sediment transport are degraded in this reach due to continued dam operation, this population is considered to be at "moderate" risk of extinction. (UWR Chinook salmon, on the other hand, are at a "very high" risk of extinction). Because there is not a hatchery component of winter steelhead, NMFS is reluctant to release winter steelhead above Big Cliff and Detroit until downstream fish passage is shown to be safe with existing structures or until new facilities are installed that provide safe passage. RM&E studies will evaluate potential benefits of steelhead passage at Big Cliff and Detroit. Based on the results of the studies, NMFS, after coordination with the FPHM, may determine that passage of UWR steelhead is appropriate during the term of this Opinion.

The effect of this RPA will be to ensure that UWR steelhead are provided safe upstream passage in the North and South Santiam subbasins, if determined feasible and necessary based on RM&Es. Lack of passage was a significant factor in the species' decline, and assuming passage is determined effective at Detroit and Big Cliff on the North Santiam and at Foster and Green Peter on the South Santiam, these populations will likely increase in abundance and productivity by allowing steelhead to use good spawning and rearing habitat above the dams.

4.3 **Willamette Fish Operations Plan: The Action Agencies will complete a Willamette Fish Operations Plan (WFOP) by October 1, 2008. The Action Agencies will coordinate with the Services when preparing the WFOP. This Plan and its annual revisions will be consistent with this Opinion and incidental take statement, and will take into account and be coordinated with related biological opinions issued by the USFWS to the fullest extent practicable. The Action Agencies will carry out measures identified in the WFOP and in annual revisions to the WFOP. The WFOP will include, but not be limited to, the following:**

1. **Identify optimal operating criteria for Green Peter, Foster, Detroit, Big Cliff, Cougar, Fall Creek, Dexter, Lookout Point, and Hills Creek dams to minimize adult and juvenile fish injury and mortality to the extent possible with existing facilities and operational capabilities;**

2. **Identify protocols for optimal handling, sorting, and release conditions for ESA-listed fish collected at USACE-funded fish collection facilities, including but not limited to those at Minto fish facility, Foster Dam fish collection facility, McKenzie Hatchery, Fall Creek fish facility, Dexter Dam fish collection facility, and at the new facilities at Cougar and Leaburg dams, when they are constructed;**

3. **Identify the number, origin, and species of fish to be released into habitat upstream of USACE dams, incorporated into the hatchery broodstock, or taken to other destinations;**

4. **Describe scheduled and representative types of unscheduled maintenance of existing infrastructure (dams, transmission lines, fish facilities, etc) that could negatively impact listed fish, and describe measures to minimize these impacts;**

5. **Describe procedures for coordinating with federal and state resources agencies in the event of scheduled and unscheduled maintenance.**

6. **Describe protocols for emergency events and deviations:**

a) **<u>Protocol Development</u>: The USACE will establish a formal, written procedure for taking actions to prevent or minimize adverse impacts to ESA-listed fish, including water quality impacts, during unusual events/conditions. These protocols will guide the actions of project personnel.**

b) **In the event of an emergency outage or malfunction, the Action Agencies will inform the Services of the emergency by phone or email, as soon as practical, but not later than 24 hours after the event. This process will also apply whenever the Action Agencies carry out flood reduction operations that result in deviations from the flow measures described in this section.**

c) **The Action Agencies may initiate work prior to notifying the Services, when delay of the work will result in an unsafe situation for people, property, or fish. For each occurrence of unscheduled maintenance and each flood damage reduction operation that results in a deviation from minimum mainstem flow objectives, minimum and maximum tributary flow objectives, ramping rates, spill at Foster Dam, or adverse TDG and water temperature conditions, the USACE will inform the Services in writing (or email) within 24 hours, and include a description of the problem, type of outage required, potential impact on ESA-listed fish, estimated length of time for repairs or flood damage reduction operation, and proposed measures to minimize effects on fish or their habitat. This approach will be taken only if it is not possible to coordinate with the Services prior to starting the maintenance event or flood damage reduction operation.**

Rationale/Effect of RPA 4.3: The WFOP will replace the Action Agencies' proposed Willamette Fish Passage and Management Plan, identified in the Proposed Action, 2007 Supplemental BA at sections 3.2.2 (p. 3-18) and 3.4.5.3 (p. 3-48). All of the features of the Action Agencies' proposed plan will be included in the WFOP, but it will also include important operational requirements not directly related to fish passage such as outflow protocols during emergencies to protect fish spawning in habitat below Project dams. The WFOP is a critical link between measures required by the Proposed Action and this RPA and on-the-ground implementation activities. The WFOP will guide Project personnel, including contractors and other agencies responsible for carrying out fish hatchery and passage measures, and will help to ensure that fish facilities are operated based on best practices and consistent with the terms of this Opinion.

By including emergency operations within the WFOP, field staff will have a single manual to rely on for all fish-related protocols, including steps that should be taken in emergency situations to minimize adverse fish effects. The notification protocols measure (number 6 in the list above) adds reporting details to a similar action described in section 3.3.4 of the Supplemental BA (USACE 2007a), and requires the Action Agencies to notify the Services within 24 hours of an unscheduled event rather than the

48 hours required by the Proposed Action measure. NMFS requires timely notification and reporting of these events in order to initiate damage assessments and to advise the Action Agencies on a preferred course of action to minimize adverse fish impacts.

The effect of this measure will be to reduce stress, injury, and mortality to adult fish caused by the Outplant Program by ensuring field personnel have clear instructions for carrying out this Program. The Plan will also minimize fish injury and mortality caused by emergency operations by providing clear directions to field staff for dealing with emergencies in a manner that is protective for listed fish. Additionally, NMFS will be able to quickly assist the Action Agencies in defining measures they should take to minimize and avoid fish losses, and NMFS will be able to assess losses when needed.

4.4 **Annual Revision of Willamette Fish Operations Plan (WFOP): The Action Agencies will annually revise and update the WFOP, including the "Fish Disposition and Outplant Protocol" sections of each chapter to describe how and where outplanted fish will be collected, held, marked, sampled, transported, and released and to incorporate changes in operations needed to protect fish. The WFOP will be revised annually based on results of RM&E activities, construction of new facilities, recovery planning guidance, predicted annual run size, and changes in hatchery management. Annual revisions will be submitted to the Services by January 15 of each year for review and comment; the Services will inform the Action Agencies by February 15, whether they agree[21] with the revised WFOP. The Action Agencies will release a final updated WFOP by March 14 of each year. Annual revisions will be considered an "Annual Milestone" as defined below in RPA measure 4.13.**

Rationale/Effect of RPA 4.4: As described above for RPA measure 4.3, the WFOP builds upon the Willamette Fish Passage and Management Plan that the Action Agencies proposed. This measure specifies dates by which the Action Agencies will release a draft plan for review by the Services, a process for review and comment on the draft plan, and a deadline for completion of the updated WFOP. This will ensure timely completion of this manual prior to the primary fish passage season each year. It will also require coordination with NMFS to ensure that proposed changes are consistent with the intent of this Opinion.

The effect of the measure is that the WFOP will be kept up-to-date with information learned from previous years' operations as well as results of RM&E studies. This new information will ensure that revised practices for handling, sorting, transporting, and releasing fish will be carried out within the next year, or sooner, after such changes are indicated by new information. As a result, UWR Chinook salmon and UWR steelhead that are collected and released above Project dams will experience less stress, injury, and mortality, and fish abundance and productivity will increase due to improved fish passage to historical habitat. Similarly, annual updates will ensure the latest information is

[21] See RPA 1.3 & 1.4 for elaboration of decision making process.

incorporated in the WFOP, and will result in reduced fish injury and mortality caused by emergency operations.

4.5 <u>**Employee Training for Fish Protection Operations at Project Dams and Fish Facilities**</u>**: The Action Agencies will ensure that fish facility personnel, operators, and managers responsible for operating and maintaining fish facilities at each project complete an annual employee environmental awareness training program. The training will include a review of the status of ESA listed aquatic species, the WFOP, and each fish facility's standard operation procedures (SOPs). Prior to conducting the annual training, the Action Agencies will coordinate with the WATER and appropriate natural resource agencies to identify any specific resource issues that should be addressed or emphasized at that time. The Action Agencies will maintain records of the training including agendas, attendance lists, and any handout materials.**

Rationale/Effect of RPA 4.5: The Proposed Action does not explicitly require staff training in how to operate fish facilities and how to handle emergencies to minimize harm to listed fish. Although hatchery personnel presently are trained to operate fish collection and transport facilities, other Project staff should be trained in emergency procedures for on-site fish facilities. If a water supply line to a fish holding pond broke and no hatchery personnel were able to respond quickly, simple directions could be given to an on-site Project operator or maintenance staff to open emergency water supply systems or otherwise provide temporary relief to trapped fish until hatchery personnel are available. The effect of this measure will be to ensure that all staff responsible for carrying out measures in the RPA and Proposed Action are well-trained in safe fish handling procedures and are able to knowledgeably and safely use mechanical equipment. The training will also ensure that fish facility personnel, as well as other Project staff, are able to quickly respond to emergencies to minimize effects on listed fish and fish habitat.

4.6 <u>**Upgrade Existing Adult Fish Collection and Handling Facilities**</u>**: The Action Agencies will design, construct, install, operate and maintain new or rebuilt adult fish collection, handling and transport facilities at the sites listed below. The Services will inform the Action Agencies whether they agree[22] with each facility's planned configuration and operation. The Action Agencies will design each facility with and incorporate NMFS' Anadromous Salmonid Passage Facility Design (NMFS 2008e) and the best available technology. During the design phase, the Action Agencies will coordinate[23] with the Services to determine if the design should accommodate possible later connection to a fish ladder, if determined necessary in future years beyond 2015.**

The Action Agencies will complete all necessary interim steps in a timely fashion to allow them to meet the following deadlines for completing construction and beginning operation of the facilities listed below. These steps may include completing a DDR and plans and specifications. The Action Agencies will give

[22] See RPA 1.3 & 1.4 for elaboration of decision making process.
[23] See RPA 1.3 & 1.4 for elaboration of decision making process.

NMFS periodic updates on their progress. The order in which these facilities are completed may be modified based on interim analyses and biological priorities, and with agreement[24] of NMFS and USFWS.

1. **North Santiam Fish Facility (currently at Minto Pond) – complete construction no later than December 2012; begin operation no later than March 2013.**
2. **Foster Fish Facility – complete construction by December 2013; begin operation by March 2014.**
3. **Dexter Ponds Fish Facility – complete construction by December 2014; begin operation by March 2015.**
4. **Fall Creek Dam Trap – complete construction by December 2015; begin operation by March 2016.**

Rationale/Effect of RPA 4.6: The Action Agencies proposed to evaluate and modify these fish facilities in Section 3.6.3 of the Supplemental BA (USACE 2007a), but did not provide certainty in when the improvements would be made or whether funding would be available to do the work. NMFS makes clear that facility improvements or replacement are required, and establishes dates to complete work and begin operation. In some cases, work could be initiated sooner than listed above, and NMFS expects the Action Agencies to make these improvements as soon as possible.

Improvements in fish trapping are needed at each of the fish collection facilities to minimize stress and injury to adult fish, as described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). Although there is no single known cause of pre-spawning mortality, stress induced during fish collection and handling is likely one component of this mortality that can be lessened by redesigning these trapping facilities using latest fish handling design criteria. Because these facilities will be used in lieu of volitional fish passage to provide access to historical habitat above the dams, this measure is an essential first step toward addressing low population numbers caused by decreased spatial distribution, which is a limiting factor for UWR Chinook salmon and UWR steelhead. This measure also addresses the critical habitat PCE factor of providing freshwater migration corridors free of obstruction, despite the fact that traps and transportation will be used to provide a migration corridor past some of the Project dams. The improvements to the fish facilities will also allow hatchery fish to be acclimated before release, a practice that will improve survival and reduce straying.

The effect of this measure is that improved collection and release of adult fish will minimize fish stress and injury, resulting in improved upstream fish passage to historical habitat. Upstream fish passage is the initial step toward restoring productivity of listed fish by using large reaches of good quality habitat above Project dams. Lack of access to good habitat above the dams, injury and mortality associated with inadequate passage facilities, and restriction to degraded habitat below the dams has caused steep declines in numbers and has reduced the functioning of PCEs of critical habitat.

[24] See RPA 1.3 & 1.4 for elaboration of decision making process.

4.7 **<u>Adult Fish Release Sites above Dams:</u> The Action Agencies, working in coordination with the U.S. Forest Service (USFS) or other applicable landowners,[25] will:**

- **Complete a site/concept study by February 28, 2009, that will identify at least four to six potential locations suitable for new adult fish release sites for Chinook salmon above Detroit, Foster, Lookout Point, Hills Creek, Fall Creek, and Cougar reservoirs. Sites located above Foster Reservoir will be suitable for releasing both Chinook salmon and winter steelhead; site(s) above Detroit and Green Peter dams should also be suitable for winter steelhead, should adult steelhead be released in these locations in future years.**
- **The Action Agencies will work with the USFS and the Services to prioritize and design each release site, which may include infrastructure to minimize stress and injury of adults (e.g., piping systems, vehicle ramps, etc). The release sites will be prioritized in the context of the Configuration Operation Plan (COP) (see RPA measure 4.13). The Services will inform the Action Agencies whether the sites as designed are consistent with the Opinion.**
- **The Action Agencies will complete construction of all selected sites by June 2012. If another entity, by December 2010, takes on the responsibility for constructing or improving these sites, the Action Agencies will not be responsible for construction of those sites completed by another entity. Additionally, if, based on results of the COP, additional sites are warranted, construction of additional sites will be completed as soon as possible after identified by the COP. Construction of the sites will be contingent upon availability of funds (which may include a non-federal cost-sharing requirement) and cooperation of landowners. Prior to construction, the Action Agencies will need to complete processes to ensure compliance with all applicable statutes and regulations not provided by this or other ESA consultations, as required by applicable law.**

Rationale/Effect of RPA 4.7: This measure builds upon one proposed by the Action Agencies in Section 3.4.5.3 of the Supplemental BA (USACE 2007a, p 3-51), but NMFS has added a minimum requirement of 4 to 6 sites, as well as dates for completion of construction and a requirement that sites above the Santiam dams be made compatible for steelhead as well as Chinook salmon release.

Improvements in release of outplanted adult fish are needed to minimize fish stress and injury, as described in the Effects sections for the major subbasins (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North

[25] NMFS acknowledges that establishment of release sites above reservoirs may be contingent upon securing funds and agreement with non-Action Agency landowners/land managers such as USFS and BLM. NMFS also understands that some entities such as USFS and BLM may elect to undertake work on the property they manage themselves, in which case Action Agencies would cooperate with them, including funding the work, if necessary. Environmental permitting not provided by this or other ESA consultations may also be required before this work can be accomplished.

Santiam, section 5.6). This is one more component (in addition to trapping facilities and handling and transport protocols described in RPA measures above) that is likely to help decrease the rate of pre-spawning mortality. Many of the existing release sites have relatively poor river access, forcing drivers to release fish using methods such as sliding fish on tarps or using collapsible hoses that elevate stress or cause direct or delayed injury or mortality. Some sites are located at river access points that experience heavy recreational pressure, leading to disturbance, harassment, or poaching of outplanted fish. New release sites will be chosen to allow safe transfer of fish from the truck, adequate recovery in pools without recreational pressure or poaching, and reasonable proximity to quality holding and spawning habitat.

The effect of this measure will be to reduce stress and associated pre-spawning mortality, ultimately increasing the percent of adult fish that successfully spawn, leading to increased productivity above the dams. This measure will also decrease adverse effects on critical habitat by providing a component of safe passage.

4.8 **Interim Downstream Fish Passage through Reservoirs and Dams: Until permanent downstream passage facilities are constructed or operations are established at Project dams and reservoirs in subbasins where outplanting of UWR Chinook salmon and steelhead is underway, the Action Agencies will carry out interim operational measures to pass downstream migrants as safely and efficiently as possible downstream through Project reservoirs and dams under current dam configurations and physical and operational constraints, and consistent with authorized Project purposes.**

Near-term operating alternatives will be identified, evaluated, and implemented if determined to be technically and economically feasible and biologically justified by the Action Agencies and Services, within the framework of the Annual Operating Plan updates and revisions and in coordination with the WATER Flow Management Committee.[26]

The Action Agencies will evaluate potential interim measures that require detailed environmental review, permits, or Congressional authorization as part of the COP (see RPA 4.13 below). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization (if necessary) and completing design or operational implementation plans for those operations selected by the COP. The measures that will be considered in the COP include, but are not limited to, partial or full reservoir drawdown during juvenile outmigration period, modification of reservoir refill rates, and using outlets, sluiceways, and spillways that typically are not opened to pass outflow. The Services will inform the Action Agencies whether they agree[27] with the interim downstream passage measures. The Action Agencies will begin to carry out measures selected by the COP by May 2011, contingent on funding, authorization, and compliance with all applicable

[26]See RPA 1.3 & 1.4 for elaboration of decision making process.

[27] See RPA 1.3 & 1.4 for elaboration of decision making process.

statutes and regulations. One specific measure is listed below, and others may be developed in coordination with the WATER, if appropriate.

Rationale/Effect of RPA 4.8: The Proposed Action describes a formidable series of studies that would be required before the Action Agencies could construct downstream fish passage structures or make major operational changes to improve downstream fish passage at Project dams and reservoirs. Although it will take many years to investigate, design, and install structural downstream fish passage facilities at those Project dams where such facilities are determined necessary and feasible, there are some fish protective measures that can be carried out in the near future without requiring significant modification to existing structures or operations. Alternative interim measures that need to be considered include short-term operations such as reservoir drawdown, pulsing flow releases, opening various valves, or spill to safely pass fish downstream through a reservoir and dam.

The magnitude of effect of these interim measures is difficult to predict because insufficient data is available to determine where these measures would take place and how successful they would be in providing downstream fish passage for juvenile Chinook and juvenile and kelt steelhead. Such measures would likely be initiated for a short time period as part of an RM&E study to determine potential effectiveness of the measure before an annual or longer term commitment is made. Studies at some non-Project dams have shown that relatively large proportions of downstream migrants pass via spill or sluiceways (see discussion of Willamette Falls Hydroelectric Project in section 4.10, Mainstem Willamette Baseline). However, until interim measures are evaluated to assess fish passage effectiveness, NMFS can only assume that these measures will result in an unquantified improvement in fish survival. This increased survival would benefit the populations of UWR Chinook and UWR steelhead in the subbasins where interim measures are used (possible in any of the following: North Santiam, South Santiam, McKenzie, Fall Creek, and Middle Fork Willamette). Improved downstream survival would help to address the spatial access VSP parameter by increasing the likelihood that the Outplant Program will result in sustainable production above the dams. Sustainable production above the dams would also improve productivity and abundance of populations by increasing the total available habitat while limiting dam-related losses. This measure will also decrease adverse effects on critical habitat by providing a component of the PCE, “migration corridors free of obstruction,” while more permanent passage options are being developed.

4.8.1 **<u>Fall Creek Drawdown</u>: Beginning in Water Year 2008, the Action Agencies will adjust timing of storage and release of flow at Fall Creek Reservoir to promote downstream passage of juvenile Chinook salmon through the reservoir and dam. Drawdown will be to at least elevation 714.0 by the end of November each year, and the Action Agencies will hold the reservoir at this elevation during all of December and January except during flood events, and possibly longer. The Action Agencies will conduct monitoring and evaluation studies to determine the effectiveness of the operation and to assist in deciding whether or not to continue the operation in future years.**

The depth and timing of the drawdown may be adjusted in subsequent years, based upon monitoring results, with NMFS' agreement.[28] During this operation, when inflow is less than Project minimum flow objectives and the reservoir is at or below 714.0', then outflow will equal inflow and this will not be considered a deviation from flow objectives.

Rationale/Effect of RPA 4.8.1: Past studies have indicated that juvenile spring Chinook salmon migrate from Fall Creek Reservoir primarily during November, and that smolts passing through the regulating outlet under conditions of lower reservoir elevations survived at higher levels than when the reservoir was held high (see Section 4.2.3 Middle Fork Willamette Baseline). Also, smolts migrating late in the season under conditions of very low head appeared to sustain lower injury or mortality rates compared to passage under high reservoir levels. If the reservoir is drawn down to an elevation below minimum conservation pool, NMFS would expect increased survival of juvenile Chinook salmon emigrating during November.

The effect of this measure will be to improve downstream fish passage survival through Fall Creek dam and reservoir, increasing productivity of the Fall Creek Chinook salmon population and ultimately resulting in increased abundance and improved spatial distribution. Another effect of this measure will be to minimize adverse effects on critical habitat by providing a component of the PCE, "migration corridors free of obstruction."

4.9 <u>Head-of-Reservoir Juvenile Collection Prototype</u>: **The Action Agencies will plan, design, build, and evaluate a prototype head-of-reservoir juvenile collection facility above either Lookout Point or Foster reservoir. If Foster reservoir is chosen for testing the prototype, the Action Agencies will design for collecting both juvenile salmonids and steelhead kelt. The Action Agencies will complete construction by September 2014. As an interim step, the Action Agencies will complete feasibility studies as part of the COP (described in RPA measure 4.13) near the end of 2010. At that time, the Action Agencies will make a "go/no go" decision on the feasibility of the prototype facility(s) and the preferred location(s) and design(s) for construction of the prototype(s). The Action Agencies will make the go/no go decision in coordination with the FPHM, and after agreement by NMFS.**

After construction is completed, the Action Agencies will conduct biological and physical evaluations of the head-of-reservoir prototype collection facilities in 2015 and 2016, with opportunities for review and comment by the FPHM and RM&E committee of study proposals and draft reports. After receiving comments, including the Services' statements regarding whether they agree[29] with the draft report, the Action Agencies will make necessary revisions to the draft report and issue a final report by December 31, 2016, on the effectiveness of the facilities, including recommendations for installing full-scale head-of-reservoir facilities at

[28] See RPA 1.3 & 1.4 for elaboration of decision making process.
[29] See RPA 1.3 & 1.4 for elaboration of decision making process.

this and other reservoirs. If the report concludes that head-of-reservoir facilities are technically feasible, capable of safely collecting downstream migrating fish, and capable of increasing the overall productivity of the upper basins, then the Action Agencies will include such facilities in the design alternatives that they consider in the COP studies described in RPA measure 4.13 below.

Rationale/Effect of RPA 4.9: This measure addresses the lack of effective downstream fish passage facilities described in the Effects sections for the major subbasins with Project dams (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). Past monitoring of downstream juvenile migration through the reservoirs and dams was minimal, although in some reservoirs (e.g., Green Peter, South Santiam, section 5.5) studies indicated that juvenile fish were not successfully migrating through the reservoir to collection facilities at the face of the dam. Regardless of whether this was caused by predation, lack of attraction to collection facilities, or another reason, these results support the notion that collecting fish near the head of a reservoir might be an effective means to achieve safe downstream passage.

Because the head-of-reservoir fish collection concept is virtually untested, it would be imprudent to require such facilities without prior field studies, design, and prototype testing to validate the concept. For this measure, NMFS defines “prototype” to refer to temporary facilities intended for concept evaluation, not long-term operations. Further, “prototype” does not necessarily refer to a single concept; multiple concepts may be experimented with simultaneously. The FPHM subcommittee of the WATER group, comprised of fish biologists and engineers with experience in fish passage design, will be an appropriate forum in which to develop concepts. NMFS’ current thinking on possible means to accomplish this is 1) floating collectors in the reservoir near the mouths of tributaries and 2) fish collection facilities on tributaries above the reservoir pools. After several years of field monitoring and conceptual design review, the Action Agencies will identify a Major Milestone (MM2) (as described in RPA measure 4.13 below) near the end of 2010 in conjunction with completion of the DDR. The major decision associated with that milestone will be "go/no go" on the feasibility of the prototype facility(s), after coordination with the FPHM and agreement by NMFS. If the decision is to construct and evaluate the prototype(s), the focus of the decision will potentially be focused on alternative location(s) and design(s) for the prototype facility(s). Among the questions to be answered are whether such a device could capture enough fish to be biologically useful, and whether it could be operated during periods of high flow and debris loading.

The effects of this measure would be to initially demonstrate whether this concept is feasible, and if so, to use head-of-reservoir facilities in Project reservoirs where indicated to increase downstream fish survival. Safe and timely downstream passage of juvenile Chinook salmon and juvenile and kelt steelhead is a critical component to the success of the Outplant Program. In order to restore access to historical habitat above Project dams, and address the spatial distribution VSP parameter, the juvenile fish produced from adults released above the dams need to safely pass through reservoirs and dams on their downstream migration. Sustainable production above the dams would improve productivity and abundance of populations by increasing the total available habitat while limiting dam-related losses. Providing access will also benefit critical habitat because lack of access was a limiting factor.

4.10 **Assess Downstream Juvenile[30] Fish Passage through Reservoirs: The Action Agencies will, in coordination with and review by the Services, assess juvenile fish passage through the following Project reservoirs:**

1. **Cougar**
2. **Lookout Point and Dexter**
3. **Detroit and Big Cliff**
4. **Green Peter and Foster**
5. **Fall Creek**
6. **Hills Creek**

These evaluations will be developed consistent with the RM&E process described below in RPA measure 9 (RM&E). The Action Agencies must seek NMFS' review of evaluation proposals. Comments submitted by NMFS on draft evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA.[31] The proposals must identify annual anticipated incidental take levels by species, life stage, and origin[32] for each year. The Services will inform the Action Agencies whether they agree[33] with the proposed studies, reports, and NEPA alternatives. The Action Agencies will begin these studies in 2008; field investigations, study reports, and NEPA analyses, if necessary, will be completed by December 31, 2015.

Rationale/Effect of RPA 4.10: Juvenile fish (and kelts) need to emigrate through reservoirs, or be transported around them, in order to continue their downstream migration and complete their life cycles. Effects are unique at each reservoir: fish may pass satisfactorily through some reservoirs, but have problems, such as loss by predation or residualism (failure to continue migrating) at others. For instance, preliminary results at Fall Creek and Cougar indicated juvenile Chinook salmon were able to safely migrate through the reservoirs, yet studies at Green Peter in the 1980s showed few fish released near the head of the reservoir reached the dam.

There is little information on fish use, migration rates, and survival in the Willamette Project reservoirs.[34] Most of the information on Project reservoir fish passage has been

[30] Include downstream steelhead kelt passage in Santiam studies through Detroit, Big Cliff, Green Peter, and Foster.
[31] See RPA 1.3 & 1.4 for elaboration of decision making process.
[32] That is, hatchery-origin or non-hatchery origin fish.
[33] See RPA 1.3 & 1.4 for elaboration of decision making process.

[34] This RPA does not include small reservoirs such as at Minto and those with the Long Tom dams.

inferred from fish traps placed below reservoirs. The kinds of studies that are needed would vary among reservoirs, depending on existing information and characteristics of each reservoir and the species that use it. If studies show that fry use a reservoir for rearing before migrating downstream as juveniles or smolts, then juvenile collection facilities at or near the face of the dam would be preferred over head-of-reservoir collection facilities. On the other hand, if juvenile fish are exposed to heavy predation while in the reservoir, then efforts would need to be directed at either head-of-reservoir collection, reducing predators or predator habitat, or reservoir operations that would encourage juvenile fish to quickly migrate downstream. In large reservoirs, currents may also be found to influence juvenile migration (vertical and horizontal distribution through the reservoir), and fish collection facilities would need to be located to take advantage of such currents. These examples show that downstream fish passage decisions regarding alternative operational and facility designs must be based on site-specific data regarding passage through reservoirs. Without this information, downstream passage facilities could be ineffective due to poorly located facilities or lack of understanding of reservoir use.

The effect of this measure will be to provide site-specific information regarding juvenile fish passage and use of Project reservoirs, informing key decisions related to downstream fish passage facilities and reservoir operations, and possibly predator management. Improved downstream fish passage will ultimately increase spatial distribution by providing safe access to and from historical habitat. This will, in turn, increase numbers of listed fish, which is needed to address the effects of the Project (depressed abundance and productivity).

4.11 <u>**Assess Downstream Juvenile Fish Passage through Dams:**</u> **At Cougar, Lookout Point and Dexter, Detroit and Big Cliff; Foster and Green Peter, Fall Creek, and Hills Creek dams, the Action Agencies will, in coordination with and review[35] by the Services, do the following:**

1. **Assess passage survival and efficiency through all available downstream routes, including turbines, spillways, regulating outlets, hatchery water supplies, etc., noting injury and mortality through each route.**
2. **Identify and propose alternatives for reducing juvenile mortality passing through the routes noted above, including, but not limited to, operational and structural modifications.**
3. **The Action Agencies will begin these studies in 2008 and will complete all field investigations, study reports, and NEPA analyses, if necessary, by December 31, 2015 (except as noted below for Cougar, Lookout Point, and Detroit in RPA measure 4.12, which have earlier completion dates).**
4. **These evaluations will be developed consistent with the RM&E process described below in RPA measure 9. The Action Agencies must seek NMFS' review of evaluation proposals. Comments submitted by NMFS on draft**

[35] See RPA 1.3 & 1.4 for elaboration of decision making process.

evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA. The proposals must identify anticipated take levels of each species and life stage for each year. The Services will inform the Action Agencies whether they agree with the proposed studies, draft reports, and alternatives.

5. **The Action Agencies will conduct additional studies in anticipation of additional passage measures constructed and operated beyond 2023.**

Rationale/Effect of RPA 4.11: The effect of lack of effective downstream fish passage facilities is described in the Effects sections for the major subbasins with Project dams (Middle Fork Willamette, section 5.2; McKenzie, section 5.3; South Santiam, section 5.5; and North Santiam, section 5.6). However, there is little existing information on downstream fish passage through various routes at Project dams. Studies are needed to determine the proportion of fish moving through existing outlets (turbines, regulating outlets, spillways, sluiceways), and their survival and injury rates through each outlet. In order to determine the likely effectiveness of downstream fish passage alternatives, studies are needed to evaluate vertical and horizontal distribution of fish as they reach the face of the dam, and to evaluate biological, technical and engineering issues associated with design of passage facilities.

The information is key to designing effective passage facilities. The kinds of studies that are needed would vary among dams, depending on existing information and characteristics of each dam and the species that use it. The focus of studies would be to develop and evaluate alternative fish passage concepts that would guide site-specific decisions and identify priorities among Project dams on the most effective downstream passage methods at each dam where it is deemed feasible and likely to be effective. If studies show that fry use a reservoir for rearing before migrating downstream as juveniles or smolts, then juvenile collection facilities.

The effect of this RPA will be to provide site-specific information regarding downstream fish passage at Project dams, informing key decisions related to downstream fish passage facilities. This information is a necessary first step in fish passage design. Improved downstream fish passage will ultimately increase spatial distribution by providing safe access to and from historical habitat.

4.12 <u>Long-Term Fish Passage Solutions</u>: **Based on the best available scientific information at the time of development of this RPA, additional structural and operational modifications are needed to allow safe fish passage and access to habitat above and below Willamette project dams.**

The Action Agencies will complete this work as part of the COP described in RPA measure 4.13 below and according to the schedule in Figure 9.4-1. The dates for completing interim steps are guidance. However, the dates for completion and operation are fixed. Measures 4.12.1 through 4.12.3 identify dates for making

structural modifications (or biologically equivalent operational measures), based on the best available information at the time of development of the RPA.

These structural or operational modifications will be analyzed and developed as high priority measures in the Willamette Configuration Operation Plan (COP) (see RPA measure 4.13). The COP will evaluate a range of structural and operational alternatives for improving fish passage and water quality conditions associated with the Willamette dams. The three alternatives described below in RPA measures 4.12.1, 4.12.2 and 4.12 .3 will be priority actions evaluated in the COP to determine whether they are biologically and technically feasible. The Action Agencies, FWS, and NMFS will evaluate the information gathered through the COP, NEPA, RM&E measures, and any other sources of information such as ESA recovery planning (including life cycle modeling developed as part of the recovery planning process), university studies, local monitoring efforts and public comment, to determine whether the scheduled action, or an alternative, will provide the most cost-effective means to achieve benefits to ESA-listed fish. If the information gathered confirms that the scheduled action is best suited to addressing the effects of the Project, the Action Agencies will proceed with implementation. If the information shows that an alternative action would provide similar biological benefits, is technically feasible, and would be more cost-effective, then the Action Agencies will implement the alternative action.[36] The Action Agencies may need to complete appropriate NEPA analyses and obtain authorization and appropriation before implementation. The Action Agencies will present specific implementation plans to NMFS, and NMFS will evaluate whether the actions proposed in the implementation plans meet the biological results NMFS relied on in its 2008 biological opinion. NMFS will notify the Action Agencies as to whether the proposal is consistent with the analysis in the biological opinion.

The Action Agencies will analyze additional structural and operational measures for downstream fish passage (beyond the three listed in measures 4.12.1 through 4.12.3 below) as part of the COP. The measures will be investigated in the same manner as for the three measures listed below. The time frame for construction and operation of these additional passage measures may extend beyond the time frame of this Opinion. However, the Action Agencies must begin certain actions, such as investigating feasibility, completing plans, conducting NEPA, if necessary, and requesting authorization, during the term of this Opinion. These studies will be included in the COP.

[36] See RPA 1.3 & 1.4 for elaboration of decision making process.

Figure 9.4-1 Willamette Project Implementation Schedule. Revised Gantt chart from the Action Agencies (USACE 2008a).

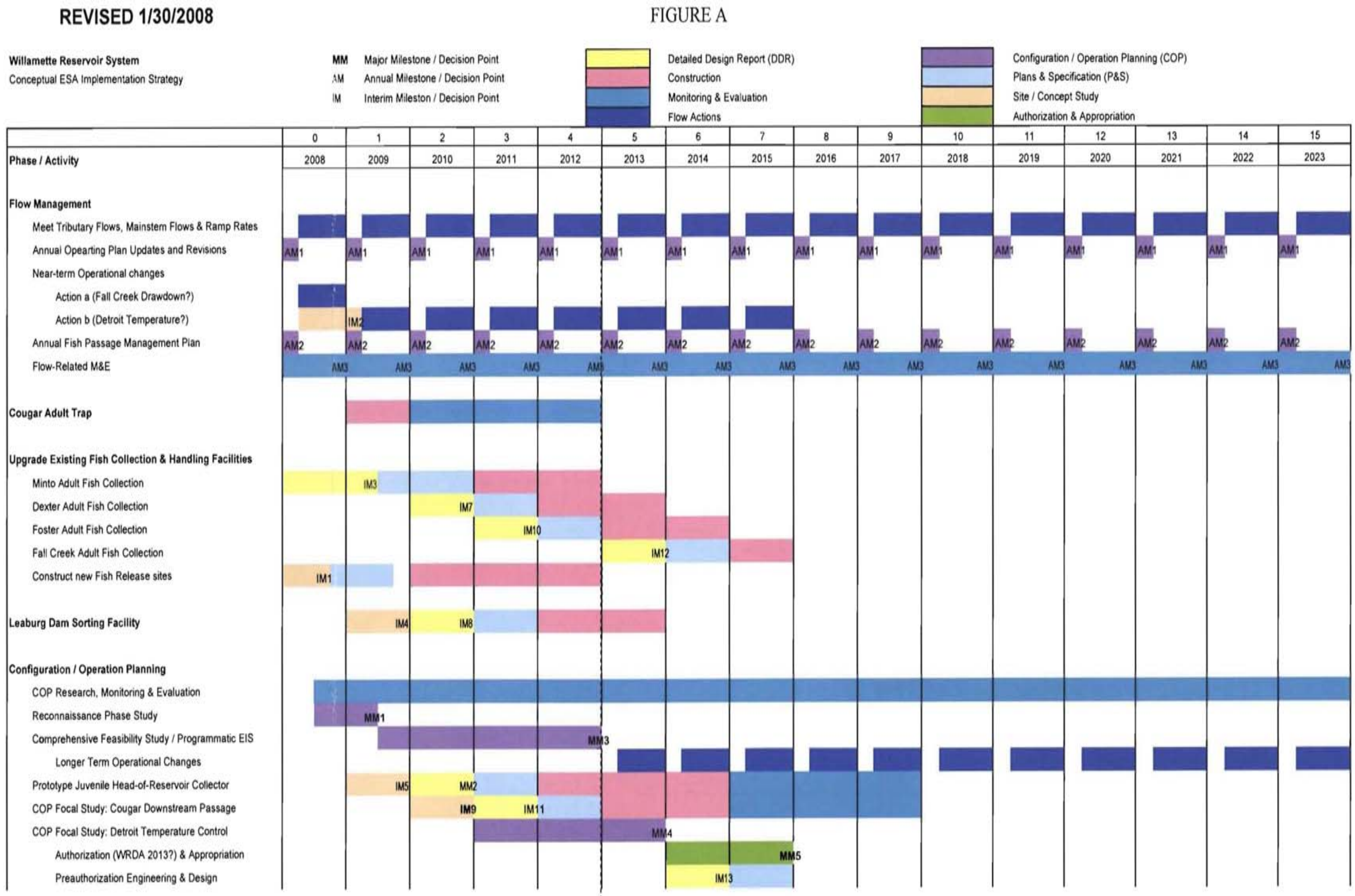

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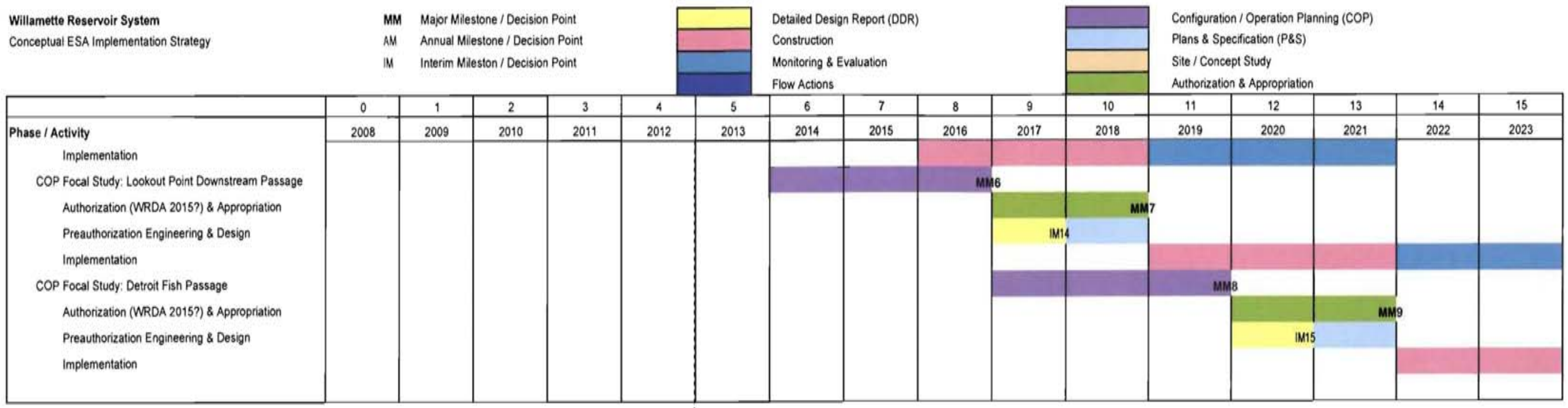
FIGURE A



***Rationale/Effect of RPA 4.12*:** This measure ensures that three major fish passage actions will be taken by the Action Agencies by specified dates. As stated elsewhere in this Opinion, lack of passage is the most significant limiting factor to the viability of the affected populations of UWR Chinook salmon and UWR steelhead. This measure addresses that effect of the PA.

NMFS chose the three sites listed in the RPA for the first three passage facilities, based on the best available information at the time of this Opinion. The choice of location of the passage facility, as well as the method of passage may change based on additional information. If information shows a different location or passage method, then the Action Agencies must coordinate with the FPHM and receive NMFS' agreement on the proposed change. Also, passage methods may vary based on the specific requirements needed at each site, as well as how the fish behave at that location.

These three passage facilities are not all that the Action Agencies will ever need to construct to address access limitation, but are sufficient in the next 15 years to begin to address the effects of the Project. By improving downstream fish passage at Cougar, Lookout Point, and Detroit dams, survival will increase for three of the four UWR Chinook populations (McKenzie, Middle Fork, and N. Santiam) and one of the two UWR steelhead populations (N. Santiam) directly affected by Project dams. However, the Action Agencies need to continue studying the next location for passage during the next 15 years so they are ready to construct and operate the next facility soon after completion of the term of this Opinion, and possibly the next one after that. Additionally, measures in an RPA must be within the Action Agencies' ability to implement. The pace of completion of passage measures is as fast as the Action Agencies can proceed.

NMFS recognizes that where fish passage was not previously authorized, the Action Agencies may need to complete appropriate NEPA analyses and obtain congressional authorization before implementation. Further, regardless of whether fish passage was previously authorized, the Action Agencies will need to obtain appropriations before project construction activities can begin.

The effect of this measure will be to ensure that passage happens at three locations within the next 15 years. This will greatly help increase numbers of UWR Chinook salmon and steelhead because they will have access to upstream habitat, and the juveniles will have access downstream to the ocean for growth to maturity. With respect to critical habitat, this measure will address the Habitat Access pathway by improving access past physical barriers, and thereby improving the status of PCEs for spawning, rearing, and migration of UWR Chinook salmon and UWR steelhead populations.

Improved downstream fish passage with will also benefit critical habitat because lack of migration corridor access was a limiting factor.

4.12.1 **<u>Cougar Dam Downstream Passage</u>: The Action Agencies will investigate the feasibility of improving downstream fish passage at Cougar Dam through structural modifications as well as with operational alternatives, and if found feasible they will construct and operate the downstream fish passage facility.**

- **The Action Agencies will take necessary initial steps beginning no later than 2010, which may include a site/concept study, design report, plans and specifications, if appropriate.**
- **The Action Agencies will establish a Major Milestone (MM2) (described in measure 4.13 below) near the end of 2010, in conjunction with completion of the Cougar Site/Concept Study and DDR. The Action Agencies will make "go/no go" decisions on the feasibility of Cougar downstream passage facilities. In the case of the decision to move forward on implementation, the decision will potentially be focused on alternative locations and designs for downstream passage facilities and operations. (NMFS assumes that fish passage improvements at Cougar Dam will not require further authorization because passage was specifically authorized and constructed as part of the original Cougar Dam plans[37]; NMFS also assumes that the proposed Cougar trap will be used for upstream fish passage.)**
- **The Action Agencies will complete construction of any structural fish passage facilities by Dec. 2014; and by 2015, begin operating downstream fish passage facilities at Cougar Dam. Any necessary NEPA compliance required for implementation of the proposed facilities will occur in conjunction with development of the DDR.**

Rationale/Effect of RPA 4.12.1-Cougar Downstream: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that will be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Cougar Dam and other Project dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.3, McKenzie Subbasin Effects, lack of access to historical spawning and rearing habitat above Cougar Dam is one of the limiting factors affecting population numbers and spatial distribution for the McKenzie Chinook salmon population. This population is at "moderate risk" of extinction and is considered a "core" and "genetic legacy" population (McElhany et al. 2007). Efforts to increase the viability of this population are essential, because it has the potential to be the stronghold for the ESU and is therefore likely to be targeted for "high" or "very high viability" in the recovery plan.

In addition to the population's status within the ESU, NMFS considers achieving safe fish passage at Cougar Dam a priority because this dam was originally authorized for fish passage, presumably making it easier for the Action Agencies to request and receive funding for this purpose. Cougar Dam originally incorporated fish passage measures, but these were abandoned due to the Project's effect on downstream water temperatures that

[37] Due to temperature changes caused by construction of the reservoir, original passage efforts failed. Since 2005, however, temperature problems have been largely solved, and passage is once again feasible.

inhibited returning adults from reaching and entering a trap at the base of the dam. Cougar Dam was upgraded in 2005 with new temperature control facilities which now make, for the first time in 40 years, collection of adults feasible below the dam. USACE plans to construct a new adult fish trap at the base of Cougar Dam in 2009. Once adults are captured in the new trap and transported above the dam, their juvenile progeny will need to emigrate out to complete their life cycles, hence the need for downstream passage at Cougar.

The effect of this measure will be to provide improved downstream fish passage at Cougar Dam, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to population growth and spatial distribution for the McKenzie Chinook salmon population, this measure will support increased abundance and productivity of this core population, reducing the likelihood that the Proposed Action will cause jeopardy.

With respect to critical habitat, this measure will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the McKenzie Chinook salmon population.

4.12.2 **Lookout Point Dam Downstream Passage: The Action Agencies will investigate the feasibility of improving downstream fish passage at Lookout Point Dam, and if found feasible, they will construct and operate downstream fish passage facilities there. The Action Agencies will take necessary initial steps, beginning no later than 2012, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate.**

- **The Action Agencies will complete construction of any structural fish passage facilities by December 2021.**
- **By March 2022, the Action Agencies will begin operating downstream fish passage facilities at Lookout Point that will enable collection and transport of fish from above Lookout Point to habitat downstream of Dexter.**
- **The Action Agencies will establish a Major Milestone (MM6) near the end of 2014 in conjunction with completion of the Lookout Point Feasibility Study. The major decision associated with that milestone will be "go/no go" decisions on the feasibility of Lookout Point fish passage facilities. Another Major Milestone (MM7) may be needed near the end of 2016 pending actions on authorization and appropriation of proposed facilities.**

Rationale/Effect of RPA 4.12.2: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that would be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Lookout Point and Dexter dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.2, Middle Fork Willamette Subbasin Effects, lack of access to historical spawning and rearing habitat above Project dams restricts spatial distribution for the Middle Fork Willamette population to a few miles of habitat below

Dexter Dam that is unsuitable for spawning and juvenile fish production due to Project effects on downstream water temperature and habitat complexity. This restricted spatial distribution is likely the most important factor limiting abundance and productivity of the Middle Fork Willamette Chinook salmon population, and without significant improvements in spatial distribution this population may be lost. Improvements to the fish collection facility at Dexter will address the upstream component of habitat access, but safe downstream fish passage past Lookout Point and Dexter is essential to ensure that the Outplant Program can successfully reestablish fish production above these dams.

The effect of this measure will be to provide improved downstream fish passage past Lookout Point and Dexter dams, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to spatial distribution for the Middle Fork Willamette Chinook salmon population, this RPA will support increased abundance and productivity of this population, increasing the likelihood that this population will trend toward a "viable" status rather than be lost. As a result, by protecting and restoring this population, there is reduced risk that the Proposed Action will cause jeopardy to the UWR Chinook salmon ESU.

With respect to critical habitat, this RPA will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the Middle Fork Willamette Chinook salmon population.

4.12.3 **<u>Detroit Dam Downstream Passage</u>: The Action Agencies will investigate the feasibility of improving downstream fish passage at Detroit Dam and if found feasible they will construct and operate downstream passage facilities. Temperature control will also be considered in designing the passage facility.**

- **The Action Agencies will take necessary initial steps beginning no later than 2015, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate.**
- **The Action Agencies will establish a Major Milestone (MM8) near the end of 2017 in conjunction with completion of the Feasibility Study. The major decision associated with that milestone will be "go/no go" on the feasibility of fish passage facilities at Detroit Dam. Another Major Milestone (MM9) may be needed near the end of 2019 pending actions on authorization and appropriation of proposed facilities.**
- **The Action Agencies will complete construction of any structural fish passage facilities by December 2023. (This measure may be completed earlier in conjunction with Detroit temperature control efforts, as described in RPA measure 5.2 below).**
- **By March 2024, the Action Agencies will begin operating downstream fish passage facilities at Detroit that would enable collection and transport of fish from above Detroit to habitat downstream of Big Cliff Dam. Any necessary**

NEPA compliance required for implementation of proposed facilities will occur in conjunction with preparation of the Feasibility Report.

Rationale/Effect of RPA 4.12.3: The Proposed Action identifies a series of field studies, alternatives analyses, and reports that would be completed, if funding is available, to assess the feasibility of downstream fish passage facilities at Detroit and Big Cliff dams, however, the Action Agencies provide no certainty that fish passage improvements will be made. As noted in Section 5.6, North Santiam Subbasin Effects, lack of access to historical spawning and rearing habitat above Project dams restricts spatial distribution for the North Santiam populations of Chinook salmon and steelhead to habitat below Big Cliff Dam. This downstream habitat is degraded by ongoing Project operations that continue to interrupt sediment transport, alter downstream water temperatures, and modify the rate and seasonality of downstream flows. Rebuilding the fish collection facility at Minto Dam below Big Cliff Dam will address the upstream component of habitat access, but downstream passage facilities are entirely lacking. Safe downstream fish passage past Detroit and Big Cliff is essential to ensure that the Outplant Program can successfully reestablish fish production above these dams.

Although NMFS has given a lower priority to this downstream passage facility than for similar facilities at Cougar and Lookout Point/Dexter dams, NMFS would prefer that this RPA be completed earlier than 2023. As described below in RPA measure 5.2, Water Quality, water temperature control facilities at Detroit Dam are scheduled to be constructed by 2018. These two measures should be evaluated and designed concurrently to ensure the design for temperature control does not preclude viable options for downstream passage. Moreover, the Action Agencies would likely achieve cost-savings and reduce operational and environmental adverse effects of construction by planning and constructing both facilities at the same time.

The effect of this measure will be to provide improved downstream fish passage past Detroit and Big Cliff dams, increasing spatial distribution by providing safe access to and from historical habitat. By addressing the primary impediment to spatial distribution for the North Santiam populations of Chinook salmon and steelhead, this RPA will support increased abundance and productivity, increasing the likelihood that these populations will trend toward a "viable" status. As a result, by protecting and restoring this population, there is reduced risk that the Proposed Action will cause jeopardy to the UWR Chinook salmon and UWR steelhead ESUs.

With respect to critical habitat, this RPA will address the Habitat Access pathway by improving access past a physical barrier, and thereby improve the status of PCEs for spawning, rearing, and migration of the North Santiam populations of Chinook salmon and steelhead.

4.13 **Willamette Configuration Operation Plan (COP): The Action Agencies will carry out the COP, a multi-year, multi-level study process, to evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs. Figure 9.4-1 identifies specific measures, studies, and milestones that will be**

accomplished through the COP. The interim steps will be completed in a timely manner; however, the dates shown in Figure 9.4-1 for interim steps are not firm. Regardless of the timing of interim steps, the Action Agencies will complete each Project measure no later than the final date listed for each measure. The Action Agencies will keep the Services appraised of their progress.

The Action Agencies will evaluate in the COP a variety of potential actions intended to benefit ESA-listed fish, including but not limited to, the following measures:

- **Upstream fish passage facilities, other than the collection facilities described in RPA measure 4.6, above;**
- **Adult fish release sites that require detailed study, as described in RPA measure 4.7, above;**
- **Interim operations for downstream fish passage that require detailed study, as described in RPA measure 4.8, above;**
- **Head-of-reservoir juvenile collection facilities that require detailed study, as described in RPA measure 4.9, above;**
- **Downstream passage facilities or operations, as described in RPA measure 4.12, above;**
- **Temperature control facilities or operations, described in RPA measure 5.2, below;**
- **Interim operations for temperature control that require detailed study, described in RPA measure 5.1, below; and**
- **System-wide operational changes, including "balancing" reservoir refill and release rates, to meet tributary and mainstem flow targets, as described in RPA measure 2.4, above.**

1. ***Definition of Milestones:*** **The COP and related actions will rely on a series of established milestones at key decision points at which the Action Agencies will coordinate and review key decisions with the Services. There will also be regular, continuous coordination between the Action Agencies, NMFS, USFWS, and other affected agencies and Tribes through the WATER process throughout implementation of proposed measures.**

There are three types of milestones identified in this RPA and defined below:

<u>Annual Milestones (AM)</u> for interagency coordination of annual and recurring activities associated with planning and implementation of ongoing ESA Measures related to operations, including completion of annual Willamette Fish Operations Plan (WFOP) revisions, and annual review of research, monitoring and evaluation (RM&E) results.

<u>Interim Milestones (IM)</u> for interim decision points in the planning and development of specific actions, including completion of site/concept studies, detailed design reports, and other key steps in the decision-making process. Interim

Milestones will include decision points on the scope, scale, and location of ESA measures under consideration with NMFS and USFWS review and comment.

Major Milestones (MM) are forecasted key points in the planning, design and implementation process involving decisions on the feasibility of major elements of the RPA and Proposed Action. They may include "go/no go" decisions on implementation of proposed major structural elements, such as fish passage or temperature control facilities, and/or significant operational changes. They may also involve decisions to shift efforts to different alternatives or priorities. Depending on decisions reached regarding the feasibility of proposed measures, it may be necessary to identify other alternatives or reinitiate ESA Section 7 consultation as a result of new information produced through the COP and related studies and coordinated through the Major Milestones.

2. ***Research, Monitoring and Evaluation:*** **RM&E will be a substantial component of the COP. The focus will be on collection and evaluation of biological and physical information required to determine the feasibility of alternative structural and operational measures under consideration in interim and major milestones. The COP RM&E program will be initiated in FY 08 and continue through the term of the Opinion. The Action Agencies will conduct an Annual Review of the Willamette COP and other related RM&E programs to review the results from previous years and revise RM&E program for upcoming years.**
3. ***Reconnaissance Phase Study:*** **The Action Agencies will initiate Phase I of the COP, the Reconnaissance Study (USACE 2007a, Section 3.6.4.3) by September 2008 and complete it by October 2009. The Reconnaissance Report will identify the range of structural and operational alternatives to be evaluated, establish preliminary basin priorities, define biological and other criteria to be used in evaluating alternatives, and provide the detailed Statement of Work for the COP Feasibility Phase. The Action Agencies will establish a Major Milestone (MM1) at the completion of the Reconnaissance Report. The primary purpose of this milestone will be to seek interagency review and concurrence on the scope and content of the subsequent Feasibility Phases. One of the key decision points at this milestone will be to review and possibly refine the priority of long term fish passage and water quality solutions for the COP (described in RPA measures 4.12 and 5.2, respectively).**
4. ***Comprehensive Feasibility Study:*** **The Action Agencies will initiate the Comprehensive Feasibility Study (USACE 2007a, Section 3.6.4.4) by October 2009 and will complete it by September 2012. The Comprehensive Feasibility Study will consider and incorporate relevant results of any life-cycle modeling developed as part of the Upper Willamette recovery planning process. If needed, the Action Agencies will complete appropriate NEPA coverage addressing the range of structural and operational alternatives addressed as part of the COP Comprehensive Study Phase. The Feasibility Report will reflect Action Agency preliminary determinations regarding the feasibility of fish passage, temperature control and other related structural and operational alternatives in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette basins. It is expected to provide specific recommendations for improvements to highest**

priority subbasins and/or features and to include recommendations for major operational changes. It will also evaluate the "high priority actions" (long term fish passage and water quality solutions described in RPA measures 4.12 and 5.2, respectively), and may suggest modifying the scope or timelines of these "high priority actions" based on the outcome of RM&E efforts.

The Action Agencies will establish a major milestone (MM3) at the completion of the COP Comprehensive Feasibility Study. At this point the Action Agencies will have completed initial studies and evaluations on a number of major alternatives, including prototype head-of-reservoir fish collection, downstream passage at Cougar Dam, and temperature control at Detroit Dam. The key decisions at this milestone are whether or not to continue toward fish passage and temperature control modifications of the dams as described in RPA measures 4.12 and 5.2, to evaluate whether or not the correct priorities were established for these measures 4.12 and 5.2, and whether other alternatives are determined more feasible. If the downstream fish passage improvements at Cougar Dam and other locations are determined not likely to be feasible at this milestone, then the Action Agencies may identify other alternatives that would be implemented within the same timelines as those identified in this RPA, or agree to reinitiate Section 7 consultation.

The Action Agencies will present specific implementation plans to NMFS, and NMFS will evaluate whether the actions proposed in the implementation plans are likely to have the biological results that NMFS relied on in this Opinion. NMFS will notify the Action Agencies as to whether the proposal is consistent with the analysis in this Opinion.

Rationale/Effect of RPA 4.13: Section 3.6.4 of the Supplemental BA (USACE 2007a) describes the Willamette System Review Study, the Action Agencies' proposal to undertake a series of studies to evaluate the feasibility and relative benefits of structural and related operational modifications to the Willamette dams designed to improve survival and productivity of ESA-listed aquatic species. The Action Agencies have changed the name of this study framework to "Willamette Configuration /Operation Planning" (COP). The Willamette System Review Study lacked certainty and commitment that fish passage, temperature control, and other improvements would be funded and completed during the term of this Opinion. As a result, the COP is significantly different than the Willamette System Review Study in that it adds certainty to the Action Agencies' proposed study by requiring firm dates for completion of specific measures.

The COP process, and NEPA when appropriate, will outline the costs of the projects, their biological benefits, technical feasibility, potential alternatives, and compliance with all applicable statutes and regulations. The analysis tool of cost effectiveness and incremental cost analysis will be used to assess the range of alternatives. An alternative plan is considered cost effective if it provides a given level of biological benefit for the least cost. Cost effectiveness analysis will be used to identify the least cost solution for each alternative that provides necessary environmental benefit. Incremental cost analysis compares the additional costs to the additional biological benefits of an alternative.

The effect of this RPA will be that the Action Agencies will complete evaluations that they state are needed to move forward on various fish passage, temperature control and other improvement projects and will then move forward with implementation of these measures. This will minimize time lost before fish protective measures are implemented and become effective at improving fish survival and habitat affected by Project facilities. With respect to critical habitat, this RPA will address the Habitat Access pathway by minimizing time lost before access is improved past physical barriers, and thereby will improve the status of PCEs for spawning, rearing, and migration of UWR Chinook salmon and UWR steelhead.

9.5 WATER QUALITY

The RPA measures in this section are based on sections 3.6 and 3.7 of the Supplemental BA (USACE 2007a). In section 3.6, the Action Agencies propose to evaluate the need and opportunities to achieve water temperature control at Project dams as part of the Willamette System Review Study. In section 3.7, the Action Agencies propose to do the following: 1) continue to operate the Cougar WTC to meet downstream water temperature targets; 2) conduct extended RM&E for Cougar WTC; and 3) carry out ongoing and new RM&E for water quality in Project-affected tributaries and the mainstem Willamette River.

NMFS agrees (in McKenzie Effects section 5.3) that continued operation of the Cougar WTC will provide more normative water temperatures in the South Fork McKenzie and mainstem McKenzie rivers, and will continue to support adult spawning, egg incubation, and fry and juvenile rearing for UWR Chinook salmon. While NMFS agrees that extensive RM&E studies are needed at Cougar to evaluate the effectiveness of the WTC and throughout the basin (General Effects, section 5.1) to monitor water quality and determine appropriate courses of action to achieve water quality standards, the Proposed Action does not provide sufficient certainty that these RM&E studies will be sufficient to provide necessary data and guide decision-making. Additionally, while NMFS agrees that further alternatives analysis is needed to identify priorities for implementing temperature control measures at Project dams (General Effects, section 5.1), the Proposed Action does not require any interim temperature control measures nor does it provide certainty that any permanent facilities will be constructed or operations will be carried out. RPA measure 5 is intended to address these issues.

The adverse effects of the Proposed Action on listed fish and critical habitat include unacceptable water temperature and TDG downstream of the Project dams where listed fish are forced to spawn because they have inadequate access to upstream habitat. The Proposed Action also causes adverse effects on critical habitat conditions downstream of the dam for the same reasons listed above. The water quality measures in the RPA will minimize these project-related adverse effects because they will make water temperatures and TDG more similar to natural conditions. The RPA measures will also provide for fish protection when there are emergencies causing the facilities to operate outside their normal procedures.

Some of the measures in this section of the RPA provide interim protection for listed fish and critical habitat by requiring the Action Agencies to implement certain temperature control measures in the next few years. These measures will address immediate needs of listed fish by providing more suitable habitat downstream of certain dams in areas used for spawning. In addition, the emergency protocols and actions will prevent further harm to listed fish and critical habitat by providing measures for listed fish protection the USACE can take immediately when emergencies arise.

RPA 5 Water Quality

5.1 <u>**Interim Water Quality Measures**</u>**: Until permanent temperature control facilities and water quality improvements are constructed or operations are established, the Action Agencies will evaluate and carry out, where feasible, interim operational measures and use existing conduits such as spillways, regulating outlets, and turbine outlets to achieve some measure of temperature control and reduced TDG exceedances below Project dams, including Detroit/Big Cliff, Green Peter/Foster, Hills Creek, Lookout Point/Dexter, Fall Creek, and Blue River.**

Rationale/Effect of RPA 5.1: Currently, listed fish are generally limited to inadequate habitat below the Project dams. Water quality problems are one of the major limiting factors in this habitat and prevent proper functioning of critical habitat directly below all of the Project dams listed above except Blue River. Therefore, until long term solutions for effective passage above the dams to properly functioning habitat are available, it is very important to make the habitat below the dams usable for listed fish.

This measure is necessary to ensure that short term actions are taken during the first 5 to 10 years of this Opinion until permanent facilities and operations are constructed and operational. Because permanent temperature control facilities such as the Cougar WTC are complex, large, and very expensive construction projects, the Action Agencies cannot build one or more in the initial years of this Opinion. However, because some of the UWR Chinook salmon populations are presently at such low abundance levels and at high risk of extinction, interim measures are needed as soon as possible to avoid further declines in abundance.

The effect of this measure will be that temperatures below one or more Project dams will more closely resemble normative conditions and TDG exceedances will be reduced, resulting in increased survival of juveniles, eggs, and adults over baseline conditions. This increased survival will help to maintain existing low populations of UWR Chinook salmon and UWR steelhead and will lead to increased productivity and abundance of those populations in affected tributaries. These interim measures will also minimize adverse project effects on critical habitat by increasing the value of critical habitat downstream of the dams by modifying temperature.

5.1.1 **Temperature Control at Detroit/Big Cliff Dams: By March 2009, the Action Agencies will complete an evaluation of the feasibility of modifying operations at Detroit/Big Cliff Dams to improve downstream temperature and TDG conditions, with the objective of achieving similar benefits to water temperature below the dams as was attained in 2007. This analysis will build on information developed during the summer 2007 emergency operation at Detroit Dam in which spill volumes were balanced with releases from the regulating outlets to achieve more desirable downstream temperatures during turbine outages.**

The Action Agencies will establish a Major Milestone (MM) to occur by March 2009, when the evaluation of feasibility is completed. If determined feasible, the Action Agencies will begin to implement the proposed operation beginning in Water Year 2009. If implemented, the Action Agencies will conduct monitoring and evaluation studies to determine the effectiveness of the operation and determine whether the operation should continue in future years. This operational alternative is considered a critical component of Configuration/Operation Planning (COP); effectiveness of using operations of existing facilities to achieve desired downstream water quality conditions will be important in future milestone decisions regarding whether or not to pursue structural water quality improvements.

Rationale/Effect of RPA 5.1.1: This measure identifies the initial location for carrying out interim temperature control measures that will address project-related adverse temperature effects on listed anadromous fish and critical habitat in the North Santiam River. Detroit Dam is a high priority for this action because interim temperature control was shown to be possible and effective in 2007, as described in North Santiam Effects section 5.6.

The effect of this measure is as described above in measure 5.1. Improved water temperatures will result in increased egg survival, as well as likely increased survival of adult and juvenile life stages, causing increases in abundance and productivity for both UWR Chinook salmon and steelhead in the North Santiam River. Another effect of this measure is to improve the value of critical habitat by improving temperature in spawning and rearing areas.

5.1.2 **Additional Interim Water Quality Measures: By March 2010, the Action Agencies will identify measures, in addition to those described in RPA measure 5.1.1 above, that they can start implementing in April 2010, if feasible. By April 2010, the Action Agencies will carry out those operational changes that will result in immediate downstream temperature and TDG benefits; and that do not require congressional authorization, detailed environmental review, extensive permitting, and that are within existing physical or structural limitations. Specific interim operational measures will be determined by the Action Agencies, with the advice of and review by the Services.**

Rationale/Effect of RPA 5.1.2: This measure provides for development of interim measures that can be easily identified and carried out at Project dams other than Detroit Dam without detailed analysis, structural modification, or additional authorization. The Action Agencies have not been able to identify such opportunities at other Project dams, but NMFS includes this measure to require the Action Agencies to assess existing gates, outlets, and operations at Project dams to determine if it is possible to mix outflow from turbines, regulating outlets or other valves with spillway flow to achieve improved downstream water temperatures while minimizing TDG exceedances. Lookout Point Dam is a priority for evaluation because monitoring shows extremely high egg mortality for UWR Chinook salmon in the very limited spawning habitat below Dexter Dam (see Middle Fork Willamette Effects section 5.2). Hills Creek Dam is another location that would likely provide immediate improvements in fish spawning and rearing habitat in the Middle Fork Willamette River below the dam downstream to the upper limit of Lookout Point reservoir.

The effect of this measure is that it may result in interim water quality improvements at more than the one or two dams listed in measure 5.1.1 above. This is an initial assessment that may or may not provide interim options, and thus, the effect on abundance and productivity of listed fish, as well as on critical habitat, is uncertain. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.1.3 **Complex Interim Water Quality Measures: The Action Agencies will evaluate measures that require detailed environmental review, permits, and/or congressional authorization as part of the COP (see RPA measure 4.13 above). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization and completing design or operational implementation plans for those operations that are determined feasible. The Action Agencies will carry out operations that are feasible by May 2011, contingent on funding, issuance of necessary permits and authorization. The Services will comment on the measures and inform the Action Agencies whether they agree[38] with the interim water quality measures.**

Rationale/Effect of RPA 5.1.3: This measure recognizes that some interim water quality improvement alternatives may include facility or operational changes that would require detailed environmental review, permits, or congressional authorization, and therefore, should be evaluated as part of the COP study (measure 4.13). NMFS distinguishes this interim measure from that in measure 5.2 below, which involves more extensive design and cost, and would be considered a more permanent solution. NMFS expects the kinds of measures that would be included here would be proposals to replace valves on regulating outlets or to install automatic controls on spillway gates. These changes are neither

[38] See RPA 1.3 & 1.4 for elaboration of decision making process.

structurally complex nor expensive, though they would likely require more detailed review than the measures contemplated in measure 5.1.2.

The effect of this measure is that interim water quality improvements may be carried out at more Project dams than contemplated in measure 5.1.2, resulting in more populations of UWR Chinook salmon and steelhead that could benefit from improved downstream temperatures and reduced TDG exceedances. However, NMFS cannot consider the effects of this measure on abundance and productivity of listed fish and critical habitat because there is no certainty that any complex interim alternatives will be carried out. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.1.4 **Monitoring and reporting of interim water quality improvement measures*:*** **Each year from 2009 through the term of this Opinion, the USACE will monitor and evaluate the effectiveness of interim and permanent water quality improvement measures, and will produce an annual report, by March 1 of the following year, for review and comment by the Water Quality/Temperature committee. The report will include recommendations, if any, to modify project operations to further improve water quality. The Services will comment on the draft report and inform the Action Agencies if they agree[39] with the recommendations.**

5.1.5 **Modifying interim water quality improvement measures: Each year from 2010 through the term of this Opinion, the USACE will carry out modified project operations proposed in the annual reports described above in RPA measure 5.1.4 unless such modifications require detailed analysis and authorization. If such additional analysis is needed, then the Action Agencies will analyze those proposed modifications as part of the COP (see RPA measure 4.13).**

Rationale/Effect of RPAs 5.1.4 & 5.1.5: Measure 5.1.4 ensures that the Action Agencies will monitor the effectiveness of interim water quality improvement measures carried out as a result of measures 5.1.1, 5.1.2, and 5.1.3, and that they will produce an annual report of their findings. Measure 5.1.5 requires the Action Agencies to use results of monitoring studies and annual report conclusions to modify interim water quality improvement measures, if indicated. NMFS recognizes in these measures that changes requiring detailed analysis, funding, or authorization will not be immediately implemented, but instead, must be considered through the COP study process.

The effect of these measures is that monitoring and reporting will give NMFS and the Action Agencies necessary information to modify water quality improvement measures to improve operations that will better protect UWR Chinook salmon and steelhead below Project dams. NMFS cannot consider effects on abundance and

[39] See RPA 1.3 & 1.4 for elaboration of decision making process.

productivity of listed fish and critical habitat because NMFS cannot predict the results of monitoring and subsequent changes that might be determined beneficial for future interim water quality improvement measures. However, it is included in this RPA because it has potential benefits to listed fish and critical habitat.

5.2 **Water Temperature Control Facilities and Operations:** **During the term of this Opinion, the Action Agencies will make structural modifications or major operational changes for improved water quality to at least one of the Project dams. Based on the best available information at the time of development of the RPA, NMFS identifies Detroit as the highest priority dam for construction of a temperature control structure or operational changes to achieve temperature control.**

The Action Agencies will investigate the feasibility of improving downstream temperatures and reducing TDG exceedances in the North Santiam River for ESA-listed fish species. The Action Agencies will take necessary interim steps beginning no later than 2010, which may include feasibility studies, a design report, authorization and appropriation, and plans and specifications, if appropriate. As part of this effort, the Action Agencies will evaluate alternatives to achieve both temperature control and downstream fish passage. If feasible and more efficient to achieve both purposes through one construction project, the Action Agencies will include downstream fish passage in this effort, rather than delaying it until 2023, as stated in RPA measure 4.12.3, Detroit Dam downstream passage. The Action Agencies will complete construction of any structural temperature control facilities by December 2018. By March 2019, the Action Agencies will begin operation of permanent downstream temperature control at Detroit Dam.

The Action Agencies will establish a Major Milestone (MM4) near the end of 2011 in conjunction with completion of the Detroit Feasibility Study. The major decision associated with that milestone will be "go/no go" on the feasibility of temperature control facilities. Because temperature control was not included as part of the original project authorization, NMFS assumes that construction of temperature control facilities at Detroit Dam may require Congressional action. Another Major Milestone (MM5) may be needed near the end of 2012 pending congressional action on authorization and appropriation of proposed facilities.

Rationale/Effect of RPA 5.2: This measure builds on the Proposed Action (section 3.6 of the Supplemental BA [USACE 2007a]), in which the Action Agencies propose to evaluate water temperature control at Project dams as part of the Willamette System Review Study. However, the Proposed Action lacks certainty that any temperature control facilities or operations would be provided during the term of this Opinion. This measure provides needed specificity and certainty by identifying a location and date certain when construction will be complete and when improved downstream temperature conditions and reduced TDG exceedances will be achieved.

NMFS chose Detroit Dam as a highest priority for water quality improvements for several reasons. First, past studies by USACE indicate that temperature control is achievable with existing storage capacity at Detroit Dam (see North Santiam Effects section 5.6.3). Second, water quality improvements in the North Santiam would benefit both UWR Chinook salmon and steelhead. Third, UWR steelhead in the North Santiam River are especially dependent on spawning habitat just below Big Cliff Dam and are more likely to be harmed by adverse water temperature conditions and TDG exceedances than steelhead in the South Santiam, which are not as confined to spawning habitat below Foster Dam. Finally, interim operations at Detroit in 2007 confirmed that restoring a more normative water temperature regime caused beneficial effects on downstream fish populations.

The effect of this measure will be that temperatures below Detroit Dam will more closely resemble normative conditions and TDG exceedances will be reduced, resulting in increased survival of juveniles, eggs, and adults over baseline conditions. This increased survival will help to increase productivity and abundance of North Santiam populations of UWR Chinook salmon and UWR steelhead. These more normative temperatures and TDG will also benefit critical habitat because they will make it more useful for listed fish.

5.3 **<u>Protecting Water Quality during Emergency and Unusual Events or Conditions</u>: The Action Agencies will apply protocols developed under RPA measure 4.3 and take actions within existing operational and structural capabilities at all project dams and reservoirs to protect water quality during unusual events and conditions.**

5.3.1 Where the protocols described in RPA measure 4.3 above cannot ensure adequate protection of water quality and other impacts to ESA-listed fish during unusual events/conditions, the USACE will identify structural or mechanical changes that could be made at project facilities for this purpose. The USACE will produce a draft report by September 1, 2009, proposing to make structural or mechanical changes to protect water quality during anomalous events.

5.3.2 With review and comment by the WATER Water Quality/Temperature committee, the USACE will produce a final report by January 1, 2010. NMFS and FWS will inform the USACE if the report's recommendations are inconsistent with this RPA.

5.3.3 The Action Agencies will begin to carry out structural and mechanical changes that will protect water quality during anomalous events and that do not require congressional authorization, detailed environmental review, or extensive permitting by March 1, 2010. These minor changes include only those that meet all of the following criteria: no need to prepare an EIS pursuant to NEPA; no need to obtain additional congressional authorization; no need to submit to extensive permitting procedures; and within reasonable cost.

5.3.4 The Action Agencies will evaluate those measures that require detailed environmental review, permits, and congressional authorization as part of the COP (see measure 4.13). The Action Agencies will complete this component of the COP by April 2011, including seeking authorization and completing design for those structural measures that are determined feasible. The Action Agencies will begin to construct and operate those measures determined feasible by May 2011, contingent on funding and issuance of necessary permits. The Services will inform the Action Agencies whether they agree[40] with the structural measures.

5.3.5 As structural and mechanical changes are completed, the USACE will update the protocols described in measure 4.3 above to include any new instructions for operating the modified facilities.

5.3.6 Any structural or mechanical improvements that are carried out will be continued through the term of this Opinion unless the Action Agencies and the Services determine, as more information is obtained, that there is a better way (that is obviously feasible) to operate for water quality.

Rationale/Effect of RPA 5.3**:** This measure requires the Action Agencies to prepare for emergency and unscheduled events that may alter water quality and cause harm to listed fish in Project reservoirs and downstream habitat. As described in North Santiam Baseline section 4.6 (and Effects section 5.6), a powerhouse fire at Detroit and Big Cliff in 2007 caused rapid increases in TDG below Big Cliff, potentially killing young steelhead alevins (the stage between hatching and leaving the gravel) as they prepared to emerge from redds below that dam. Had protocols been in place that described ways to avoid and minimize harmful effects of emergency conditions on water quality and fish, these actions could have been carried out immediately by Project staff, thereby reducing the number of steelhead alevins that would have been killed.

The effect of this measure will be that actions to minimize fish harm from emergency events will be identified in advance, and will then be carried out as soon as possible after such events occur, resulting in less injury and mortality to listed fish above and below Project dams. Additionally, because this measure requires the Action Agencies to investigate and carry out structural or mechanical changes determined feasible to protect water quality during emergency events, fish losses will be further reduced.

5.4 **<u>Cougar Dam RM&E</u>: The Action Agencies will fund and carry out an extended biological RM&E program associated with the Cougar Dam WTC. The RM&E program will begin in 2011, after completion of the RM&E program included in the previously authorized Cougar Trap project. The RM&E program will evaluate effects of the WTC operation on the downstream ecosystem (including TDG), fish passage through the reservoir, dam, and regulating outlet, and effectiveness of the trap-and-haul program. It will also quantitatively assess biological benefits realized**

[40] See RPA 1.3 & 1.4 for elaboration of decision making process.

from these protective and restorative measures. By September 2010, the Action Agencies will prepare a revised Cougar Dam WTC Monitoring and Evaluation Plan, based on the original plan developed as part of a previous consultation, subject to review and comment by the Services, and consistent with the RM&E process described below in RPA measure 9 (RM&E). The Action Agencies must obtain NMFS' review of the plan prior to initiating any research-related activities anticipated in this RPA. The proposals must identify anticipated take levels of each species and life stage for each year. The Services will inform the Action Agencies whether they agree[41] with the revised plan, proposed studies, draft reports, and NEPA alternatives. The Action Agencies will begin to carry out the extended RM&E program by March 1, 2011.

Rationale/Effect of RPA 5.4: This measure modifies a similar action described in section 3.7.1.2 of the Supplemental BA (USACE 2007a). The Proposed Action does not specify when this RM&E program would begin, or how it would mesh with ongoing monitoring at Cougar Dam. Monitoring the Cougar WTC and associated fish passage at that facility is already required thru at least 2010 as part of the Cougar Trap project, and NMFS completed consultation on that proposed action in 2007 (NMFS 2007a). In this measure, NMFS requires the Action Agencies to continue RM&E at Cougar Dam beginning in 2011 to ensure that studies include a sufficient number of years of data to represent a variety of water year conditions and to include adult return data.

The effect of this measure will be to ensure that decisions regarding temperature control and downstream passage at Cougar Dam and other Project dams are based on reliable biological information. As a result, existing structures will be operated to improve fish survival and new structures will be more likely to provide safe fish passage and favorable water quality conditions for listed fish below Project dams.

9.6 HATCHERIES

The following actions are included in the RPA for Hatcheries. These actions are necessary for reducing short- and long-term risks faced by the Chinook ESU and steelhead DPS, thereby increasing the viability of the affected populations.

RPA 6 Hatcheries

6.1 **The Action Agencies will work cooperatively with the State of Oregon to ensure that Willamette Project hatchery programs are not reducing the viability of listed ESUs/DPSs.**

6.1.1 **Implementation of Hatchery and Genetic Management Plans (Willamette Basin-wide): The Action Agencies will implement the actions described in the Willamette Hatchery and Genetic Management Plans (ODFW 2003, 2004a, 2005a, 2007a, 2008a, 2008b) for spring Chinook, summer steelhead,**

[41] See RPA 1.3 & 1.4 for elaboration of decision making process.

and rainbow trout, after NMFS approval of these plans. Implementation of these actions requires cooperation with the State of Oregon, who partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.

***Rationale/Effect of RPA 6.1.1*:** The HGMPs provide the detailed management plan for each hatchery program throughout the entire life cycle of the fish. Adherence to the HGMP is necessary since the fine details of the hatchery programs are not (and should not be) included in the Supplemental BA.

The effect of this measure will be to reduce and minimize adverse effects of hatchery programs on UWR Chinook and steelhead. There are many specific protocols and guidelines for spawning, raising, and releasing hatchery fish that need to be implemented to be in accordance with best management practices for reducing impacts to ESA-listed stocks.

6.1.2 **Hatchery Facility Improvements (Willamette Basin-wide): The Action Agencies will improve fish collection facilities associated with the hatchery mitigation program; including salmonid ladders, traps, holding, and acclimation facilities associated with hatchery broodstock collection and the outplanting program. Facilities will be rebuilt according to the schedule described in RPA measures 4.6 and 4.7 above.**

Rationale/Effect of RPA 6.1.2: Improving the collection facilities associated with hatchery broodstock collection and the outplanting program of fish above the dams is necessary in order to reduce the handling impacts to listed fish associated with using the existing facilities. The existing facilities were not designed (nor originally intended) to capture and handle listed fish.

The effect of this measure will be to reduce handling stress and mortality to listed salmon and steelhead associated with the collection of fish associated with the outplanting program above the dams and hatchery broodstock collection.

6.1.3 **Mass-marking of Hatchery Releases (Willamette Basin-wide):- The Action Agencies will continue to mark all hatchery fish releases in the Willamette Basin with an adipose fin clip and otolith mark. The Action Agencies will ensure that coded wire tags (or blank tags if appropriate) will be inserted into all hatchery spring Chinook released into the McKenzie Basin, beginning with the 2008-09 smolt releases. The Action Agencies, with the cooperation of the ODFW, will phase in the tagging of all other Chinook releases according to the schedule described in RPA measure 4.13 above, so that the first year of the age-4 return can be detected at the rebuilt facilities. There is no need to wire tag Chinook releases unless infrastructure is in place to detect adult returns.**

Rationale/Effect of RPA 6.1.3**:** It is necessary to continue to externally mark all hatchery fish releases so that (1) the status of natural-origin and hatchery-origin returns can be determined, (2) the percentage of hatchery fish spawning naturally in the wild can be determined, and (3) so that managers can incorporate natural-origin fish into hatchery broodstocks as appropriate.

The effect of this measure will be to ascertain effects of the hatchery program on the natural-origin population in terms of the percentage of natural-origin fish collected for broodstock and percentage of hatchery fish on the natural spawning grounds.

6.1.4 **Improvements at Leaburg Dam (McKenzie): The Action Agencies will fund the design, construction, and operation[42] of a sorting facility at Leaburg Dam on the McKenzie River to reduce hatchery fish straying into core spring Chinook natural production areas upstream. Modification of the existing facilities, or construction of new ones, is contingent on agreement by the facility owner, Eugene Water & Electric Board (EWEB), and collaboration with EWEB and ODFW. The Action Agencies will establish a Working Group, comprised of representatives from BPA, USACE, NMFS, ODFW, and EWEB, to scope the design and implementation of the sorting facility. The design philosophy for this facility will be that it automatically separates hatchery-origin adults from other fish.[43] If it is not feasible to design the facility with automatic sorting capability, the Action Agencies will seek NMFS' agreement[44] to use an alternative facility design that minimizes harm to UWR Chinook salmon. The Action Agencies will complete construction of the sorting facilities by December 2013, and begin operation in time for the spring Chinook upstream migration beginning in 2014. If an acceptable sorting facility at this site is deemed infeasible by the Working Group and agreed to by NMFS, then the Action Agencies will take alternative actions to reduce hatchery fish straying to less than 10% of the total population spawning in the wild.**

Rationale/Effect of RPA 6.1.4**:** The McKenzie run of Chinook is a stronghold population and currently produces the highest number of natural-origin fish in the ESU. Significant spawning by hatchery-origin fish (13-36%) in the wild presently occurs and represents substantial risks to population productivity and diversity. It is necessary to reduce the effects of hatchery fish on this population to the lowest extent possible (0-10%) in order to restore this population and to be able to evaluate its sustainability without the continual infusion of hatchery spawners.

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[42] Operation could be partially or completely funded by another entity.
[43] Hatchery-origin fish have had small metal tags implanted in them. These tags may be electronically sensed and the resulting signal used to operate sorting devices. Non-hatchery origin fish do not have these tags and could theoretically be allowed to pass upstream without human intervention, reducing the injury and stress that they experience.
[44] See RPA 1.3 & 1.4 for elaboration of decision making process.

The effect of this measure will be to reduce the natural spawning of hatchery fish in the wild, thereby reducing risks of genetic introgression.

6.1.5 **<u>Management of Hatchery-origin Spring Chinook Upstream of Cougar Dam (McKenzie)</u>: The Action Agencies will discontinue releases of all hatchery spring Chinook salmon above Cougar Dam on the South Fork McKenzie River once sufficient numbers of wild fish can be safely collected at the rebuilt Cougar Dam trap and outplanted above the dam. The minimum number of wild fish needed for the outplanting program will be determined by the Fish Passage and Hatchery Management Committee. If insufficient numbers of wild fish (e.g., less than 100 wild fish) are collected at Cougar Dam, then hatchery fish may be used to supplement natural spawning above Cougar Dam, up to a maximum of 50% of the outplanted fish. The FPHM committee will annually update the Willamette Fish Operations Plan with the appropriate number of hatchery-origin fish to be released upstream of Cougar Dam.**

Rationale/Effect of RPA 6.1.5**:** The continual outplanting of adult hatchery fish above Cougar Dam represents significant productivity and diversity risks to the McKenzie population because offspring from these outplanted fish (i.e. F1 hatchery fish) would be indistinguishable from natural-origin fish in the population. These fish would then spawn naturally in the population, thereby infusing hatchery genes into the wild population. The continual release of hatchery fish upstream of Cougar Dam is inconsistent with RPA measure 6.1.4 and continues to allow hatchery fish to influence the natural-origin population. This measure includes cooperation with the State of Oregon, who partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.

The effect of this measure will be to manage genetic introgression of hatchery fish in the McKenzie population and facilitate local adaptation of a self-sustaining run of spring Chinook upstream of Cougar Dam in the South Fork of the McKenzie.

6.1.6 **<u>Improve Summer Steelhead Release</u>: The Action Agencies, in cooperation with ODFW, will improve the release of hatchery summer steelhead smolts by allowing volitional emigration from the point of release over an extended period of time (e.g., 2-4 weeks) with any non-migrants being removed and not released into free flowing waters below the Projects, to extent possible given constraints on the current infrastructure. When the facilities are reconstructed, the Action Agencies will ensure that any new acclimation facilities allow for this operation.**

Rationale/Effect of RPA 6.1.6**:** Improving the release protocols for hatchery summer steelhead smolts should reduce the percentage of hatchery fish that residualize and thus interact with listed fish below the dams. Previously management practices released all of the fish into the river and did not remove fish that were not ready to actively emigrate to the ocean.

The effect of this measure will be to reduce competition and predation of hatchery fish on natural-origin Chinook and steelhead downstream of the dams.

6.1.7 **<u>Reduce Summer Steelhead Recycling in the Santiam Basin</u>: The Action Agencies, in cooperation with ODFW, will stop recycling adult summer steelhead for fishery harvest purposes by September 1st of each year in the North Santiam and South Santiam rivers. The Action Agencies will continue to operate fish collection traps on a weekly basis through October 15th in order to maximize the collection of summer steelhead, to the extent possible with the current facilities. These fish will then be held at the hatchery for spawning, unless determined otherwise by the FPHM committee.**

***Rationale/Effect of RPA 6.1.7*:** Previously, summer steelhead were periodically recycled through the end of October for sport fisheries downstream of the dams. The practice of recycling fish later in the season (i.e. September through October) when fishery effort is low and the fish are nearing spawning time likely increases the number of summer steelhead that spawn in the wild during the fall and winter. Eliminating the recycling program later in the season and removing the summer steelhead that are captured in the traps will decrease the number of naturally-spawning summer steelhead.

The effect of this measure will be to reduce straying and spawning by summer steelhead in listed winter steelhead habitat and reduce competitive interactions between juvenile summer and winter steelhead.

6.1.8 **<u>Adjust Releases of Summer Steelhead in the Santiam Basin</u>: The Action Agencies, in cooperation with ODFW, will reduce the hatchery summer steelhead release in the North Santiam River to 125,000 smolts. To offset this reduction, summer steelhead releases may be increased in one or more of the following subbasins: South Santiam, McKenzie, and Middle Fork Willamette (up to a total of 36,000 fish) to maintain the existing hatchery mitigation in the Willamette Basin. The revised HGMP for summer steelhead will identify how these production changes will be allocated among the different rivers.**

***Rationale/Effect of RPA 6.1.8*:** Recent creel survey data shows the sport fishery in the South Santiam catches more summer steelhead than in the North Santiam (Schroeder et al. 2006). However, more hatchery fish are released in the North Santiam than the South Santiam. The combination of greater hatchery fish released and lower fishery harvest in the North Santiam is leading to widespread spawning by hatchery summer steelhead in the listed winter steelhead habitats. Adjusting the release numbers in the North and South Santiam to be more aligned with current fishery needs, and will allow greater harvest and reduce impacts to winter steelhead.

The effect of this measure will be to reduce spawning of summer steelhead in listed winter steelhead habitat of the North Santiam, thus reducing adverse effects of the hatchery program. More fish released in the South Santiam will provide more harvest in the sport fishery, where fishing effort is greater. Harvest of summer steelhead will likely increase, and thus straying and spawning by summer steelhead should not increase appreciably.

6.1.9 **Future Summer Steelhead Management Actions: The Action Agencies, in cooperation with ODFW, will implement future management actions aimed at reducing the impacts of the summer steelhead hatchery program on ESA-listed species. These actions will be developed according to the process described in section 3.4.10.2 of the Supplemental BA (USACE 2007a), which will incorporate the results of research, monitoring, and evaluation.**

Rationale/Effect of RPA 6.1.9: If RM&E in the near future continues to show unacceptable straying and spawning by summer steelhead in the DPS after recent management changes have been implemented, then further actions to reduce impacts will be developed and implemented as necessary.

The effect of this measure will be to adaptively manage the summer steelhead hatchery program and thus guide future management decisions that could reduce impacts on listed winter steelhead.

6.2 **The Action Agencies will preserve and rebuild genetic resources through conservation and supplementation objectives to reduce extinction risk and promote recovery. These actions rely in part on cooperation with the State of Oregon, which partially funds and operates many of the facilities associated with the Hatchery Mitigation Program.**

6.2.1 **Implementation of Hatchery and Genetic Management Plans (Willamette Basin-wide): When approved by NMFS, the Action Agencies, in cooperation with ODFW, will implement the actions described in the NMFS-approved Willamette HGMPs for spring Chinook, summer steelhead, and rainbow trout.**

Rationale/Effect of RPA 6.2.1**:** This measure is identical to that described as RPA measure 6.1.1, but is included here because of the importance of HGMPs to practices that rebuild genetic resources.

6.2.2 **Genetically Integrated Management of Spring Chinook Programs (Willamette Basin-wide): For all Willamette spring Chinook hatchery mitigation programs, in each population area (Middle Fork, McKenzie, South Santiam, North Santiam), the Action Agencies, in cooperation with ODFW, will fund and implement conservation and supplementation programs that build genetic diversity using local broodstocks and manage the composition of natural spawners according to the sliding-scale matrices,**

as described in Section 3.4 of the Proposed Action, Supplemental BA (USACE 2007a, and ODFW 2003,2004a, 2005a, 2007a, 2008a, 2008b). The Action Agencies will monitor and evaluate implementation of actions through the end of the ESA take coverage period (term of this Opinion is 15 years).

Rationale/Effect of RPA 6.2.2: Since the hatchery Chinook programs are being used for reintroduction efforts above some of the impassable dams, based upon the best available science, it is necessary for the hatchery stock to be integrated with the natural-origin population to the extent possible at this time. Therefore natural origin fish must be incorporated into the hatchery broodstocks. In addition, hatchery fish will be managed on the spawning grounds to manage genetic risks to the wild population over the long-term.

The effect of this action will be to make the Chinook hatchery stocks as similar as possible to their respective natural-origin counterparts to the extent possible. This will reduce domestication and genetic risks of hatchery fish to the natural-origin population above and below the dams.

6.2.3 **Continue Adult Chinook Outplanting Program (Willamette Basin-wide):- The Action Agencies will continue the existing Adult Chinook Salmon Outplanting program, capturing spring Chinook salmon below USACE projects and transporting them into habitat that is currently inaccessible above the following dams: in the North Santiam, above Detroit Dam; in the South Santiam, above Foster Dam; in the South Fork McKenzie, above Cougar Dam; and in the Middle Fork Willamette, above Lookout Point and Hills Creek dams; and carry out the operational and handling protocols described in the HGMP for each subbasin hatchery. The Action Agencies will use hatchery fish in each population area as described in the HGMP sliding scale matrices. See RPA measures 4.1 through 4.4 of this RPA for additional details.**

***Rationale/Effects of RPA 6.2.3*:** For several Chinook populations (North Santiam, South Santiam, Middle Fork Willamette), it is necessary to use existing hatchery stocks for outplanting efforts above the impassable dams because of the lack of natural-origin fish available. Since the dams blocked most of the historical holding and spawning habitat in these populations and there are problems with water temperature below the Projects, it is necessary to regain production from the areas upstream of the dams, even though hatchery stock will be used for reestablishing the fish above the dams. This measure relies on the Action Agencies working in cooperation with ODFW.

The effect of this measure will be to re-establish natural production in historical habitat above impassable dams. Since the outplanting program has significant impediments at this time with the trapping facilities, prespawning mortality, downstream passage of juvenile fish through the reservoirs and dams, the use of hatchery fish is more appropriate in many cases than using natural-origin fish.

6.2.4 **<u>Adjust Spring Chinook Release Strategy (Willamette Basin-wide)</u>: The Action Agencies will use more natural (i.e. "wild-type") growth rates and size at release for all juvenile spring Chinook reared and released at hatcheries, as feasible. Actions shall be taken to release hatchery fish that are more similar to their natural-origin counterparts to the extent feasible. As proposed in the Supplemental BA, the Action Agencies will work with ODFW to develop a plan for an experimental release in 2009, with an associated RM&E program. The FPHM Committee will evaluate RM&E results, current science on release strategies, and additional information resulting from analysis of previous releases, to develop a plan for modifying future releases. These Chinook hatchery programs serve a dual purpose (fishery augmentation and population conservation), thus consideration shall be given to the survival effects of this hatchery reform action. Unacceptably low survival rates would prevent attainment of both conservation and fishery objectives.**

***Rationale/Effects of RPA 6.2.4*:** Since hatchery Chinook are being used for conservation purposes, it is necessary to align hatchery fish to the extent possible with the natural-origin population. The hatchery fish, when released as smolts, are larger than wild smolts, which has implications for survival, age at return, and reproductive potential. This RPA action will experiment with different release strategies to align hatchery smolts more with wild smolts with the intent of reducing hatchery effects on population viability.

The effect of this measure will be to make the hatchery Chinook more similar to their natural-origin counterparts, thus making them more appropriate for supplementation and reintroduction purposes.

6.2.5 **<u>Molalla River Chinook Recovery:</u> The Action Agencies will support ODFW efforts to eliminate the use of the non-local hatchery Chinook stock (South Santiam) released into the Molalla River. The Action Agencies will work with ODFW to identify potential funding and implementation mechanisms to develop a locally-adapted broodstock, using the conceptual approach described in the hatchery management strategy for the Molalla River Basin.**

***Rationale/Effects of RPA 6.2.5*:** The best available science suggests a locally-derived hatchery stock is better for supplementation purposes than an out-of-population and/or domesticated hatchery stock. The proposed action is to continue to release South Santiam hatchery stock into the Molalla River. Development of a locally derived Chinook broodstock would contribute to recovery efforts in the Molalla River by addressing the effects of the Project.

The effect of this measure will be to reduce impacts of the existing hatchery stock on the population. A locally-derived stock is likely to be more fit to local environmental conditions and more productive.

9.7 HABITAT

This section of the RPA is intended to build upon the measures described in Section 3.5, Habitat Restoration and Management Actions, of the Supplemental BA (USACE 2007a). For the most part, the Proposed Action measures involve assessment of habitat needs and studies to identify and prioritize possible restoration projects, if funding is available. In this Opinion, Section 5, Effects, NMFS describes adverse effects of continued operation of Project dams and maintenance of Project revetments on downstream physical habitat (See Middle Fork Willamette Section 5.2.4; McKenzie Section 5.3.4, etc). The Proposed Action would continue to degrade existing rearing, holding, and spawning habitat below Project dams, reducing abundance and productivity of UWR Chinook salmon and UWR steelhead. Additionally, as described in the Habitat Access and Fish Passage subsections within key tributary sections of Effects (Middle Fork Willamette Section 5.2.1, McKenzie Section 5.3.1, South Santiam Section 5.5.1, and North Santiam Section 5.6.1), the Proposed Action would continue to prevent safe access to historical habitat above the dams, restricting most of the fish to existing habitat below the dams. Thus, during the term of this Opinion, while fish passage solutions are being researched and installed at the highest priority Project dams, the Action Agencies must actively restore habitat downstream of the dams to offset continued degradation in this remaining habitat. Further, as described in Section 3, Rangewide Status, juvenile rearing habitat in the lower reaches of most tributaries is one of the key factors limiting productivity of most populations of UWR Chinook salmon. Even after other limiting factors are addressed that increase productivity (e.g., water temperature and/or fish passage), restoration of juvenile rearing habitat in reaches downstream of the dams will still be necessary to ensure adequate habitat is available for this life stage. Habitat restoration work will prevent further declines in abundance and productivity of UWR Chinook salmon and UWR steelhead associated with Project effects on downstream habitat, and will be necessary to ensure success of other actions required in this RPA by addressing limiting factors associated with other life stages.

7.1 **Willamette River Basin Mitigation and Habitat Restoration: The Action Agencies will plan and carry out habitat restoration programs on off-site lands. Existing programs will continue (7.1.1); a comprehensive program will be established (7.1.2); and additional projects will be done (7.1.3). The purpose of the program will be to protect and restore aquatic habitat to address limiting habitat factors for ESA-listed fish.**

7.1.1 The Action Agencies will continue to carry out the projects listed in Table 9.7-1 (below).

Table 9.7-1 Ongoing Habitat Restoration Projects in the Willamette Basin

Project/Program	Water Body	Description
Willamette Basin Mitigation (BPA 199206800)	Mainstem Willamette	Integrative mitigation program that protects, conserves, and restores areas containing diverse habitats that assist the life history needs and resources for multiple terrestrial and aquatic species in the Willamette Basin.
Delta Ponds (Section 206, USACE)	Mainstem Willamette near Eugene	Construction initiated in 2005 with the City of Eugene, and will continue. The project is providing floodplain and hydraulic connectivity to the Willamette River through a series of old gravel pits.
Springfield Millrace (Section 206, USACE)	Middle Fork Willamette near Springfield	Construction initiated 2008 with the City of Springfield. The project will restore historic millrace and mill pond and creation of wetlands, fish passage and water quality improvements.
North Santiam Gravel Study (Planning Assistance to States, USACE)	North Santiam River	This study was initiated in 2008 and will assess the need and potential locations for gravel placement in the North Santiam River.

7.1.2 The Action Agencies will develop and carry out a comprehensive habitat restoration program, in collaboration with the Services, which will include funding for carrying out habitat restoration projects during the term of this Opinion. The Action Agencies will work with the Services to pursue authorization, if necessary, and appropriations to carry out the habitat restoration program.

The Action Agencies will work closely with the Services to accomplish the following:

1. **Develop project selection criteria aimed specifically at addressing factors limiting the recovery of Willamette basin ESA-listed fish populations, focusing on, but not limited to, those factors caused at least partially by the Willamette Project. These criteria should be informed by regional plans including Willamette Basin Recovery Plans for anadromous salmonids (ODFW 2007b), Willamette Aquatic Habitat Assessment (unpublished, see RPA measure 7.5), Willamette Subbasin Plan (WRI 2004), Willamette River Basin Planning Atlas (Hulse et al. 2002), and the COP evaluation (measure 4.13).**
2. **Identify proposals for habitat restoration projects.**
3. **Forward those proposals that meet project selection criteria to NMFS for review and determination if they are consistent with improving survival and recovery.**
4. **Fund priority projects, through applicable programs and processes (see Table 9.7-2), that NMFS and FWS determine to be consistent with recovery plans for their respective ESA-listed species.**

Table 9.7-2 Authorities/Programs to Facilitate Implementation of Habitat Restoration Projects in the Willamette Basin

Program	Water Body	Description
Columbia River Basin Fish and Wildlife Program	Columbia Basin (including Willamette)	The Northwest Power Act of 1980 directs the Council to develop a program to protect, mitigate and enhance fish and wildlife of the Columbia River Basin that have been impacted by hydropower dams, and make annual funding recommendations to the Bonneville Power Administration for projects to implement the program. The Bonneville Power Administration then decides which projects to fund and implements the selected projects.
Continuing Authorities Program (CAP); (USACE Sections 206 & 1135 Programs)	Oregon	Continuing Authorities Program funds small restoration projects that address a variety of water resource and land related problems. A description of the CAP program is provided in section 3.5.2.3 of the Supplemental BA (USACE 2007a)
General Investigation Program (GI); USACE)	Oregon	Authority to conduct complex, large-scale, multiple purpose water resource projects. Applicable existing GI studies are described in Section 3.5.2.2 of the Supplemental BA and include: the Willamette River Floodplain Restoration Study; Eugene-Springfield Metro Area Watershed Feasibility Study, Lower Willamette Ecosystem Restoration Feasibility Study
Planning Assistance to States (PAS); USACE)		Authority to work with non-Federal sponsor to study and evaluate water and related land resource problems. Current study of North Santiam Gravel under this authority
Upper Willamette Watershed Ecosystem Restoration Authority (USACE Sec 3138 program)	Willamette watershed upstream of Albany	New authority from WRDA 2007 to conduct ecosystem restoration studies for the upper Willamette basin to protect, monitor, and restore fish and wildlife habitat.
Ecosystem Restoration and Fish Passage Improvement Authority (USACE Sec 4073)	Oregon	New authority in WRDA 2007 to conduct studies for ecosystem restoration and fish passage improvement on rivers throughout Oregon. Emphasis on fish passage and restoration to benefit species that are ESA listed. In conjunction with study, pilot project to demonstrate effectiveness of actions is authorized.
Sustainable Rivers Partnership with The Nature Conservancy	Willamette Basin	Cooperative agreement between USACE and The Nature Conservancy to assess and implement dam operational changes to better mimic natural river flows in the Willamette basin

7.1.3 By 2010, the Action Agencies will complete at least two of the highest priority projects that should result in significant habitat improvement for listed fish species. The Action Agencies will complete additional habitat projects each year from 2011 through the term of this Opinion. Alternatively, larger projects that might require several years to complete could be funded over a multi-year period instead of funding individual, smaller projects each year. NMFS will inform the Action Agencies whether they agree with the decision to fund and carry out these projects.

Rationale/Effect of RPA 7.1: This measure builds on the multiple studies and authorities the Action Agencies describe in the Proposed Action, section 3.5.2 through 3.5.4, of the Supplemental BA (USACE 2007a). It requires the Action Agencies to develop, fund, and carry out a comprehensive habitat restoration program for listed fish species in the Willamette basin.

Measure 7.1.1 acknowledges continued funding of existing projects in the Willamette watershed that provides some habitat improvements for UWR Chinook salmon and UWR steelhead. Although NMFS proposes to redirect project priorities to benefit these listed species, most of the funds for these projects have already been committed for other purposes, so only a small number of projects might be funded through this process. The Willamette Basin Mitigation project has some benefit, although limited, because it is directed primarily at terrestrial species. The Willamette Basin Mitigation projects will primarily benefit UWR Chinook salmon and UWR steelhead, and to a lesser degree, LCR Chinook salmon, LCR steelhead, and LCR coho salmon.

The priority for the new program and restoration projects described in RPA measures 7.1.2 and 7.1.3 is to maximize benefits for listed fish populations for which habitat degradation due to the Project is a major limiting factor. NMFS expects that most funded projects will have ecological benefits beyond helping listed fish species. Although specific projects are not identified, this measure provides enough certainty that the Action Agencies will establish a program, identify priority projects, acquire funding, and complete at least 2 projects by 2010, with additional projects funded and completed each year from 2011 through 2023, the term of this Opinion. This measure on its own would not be sufficient to offset continued population declines associated with degraded downstream habitat, but it does ensure an incremental improvement in downstream habitat, and would help to maintain populations at existing levels below the dams.

The effect of this measure is to offset adverse impacts of the Willamette Project on elements of critical habitat, such as degraded rearing and migration habitat in the mainstem Willamette and lower reaches of its tributaries caused by reduction in channel-forming flows and continued existence and maintenance of revetments. This measure will offset the effects by creating complex rearing habitat, adult holding habitat, and access to off-channel habitat, resulting in increased abundance and productivity of UWR Chinook salmon and UWR steelhead, and will improve the functioning of the PCEs for safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. If any projects are funded in the Willamette River below the falls, LCR Chinook salmon, LCR steelhead, and LCR coho salmon would also see small increases in abundance and productivity.

Some restoration projects will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2008e). The positive effects of these projects on population viability and PCEs will be long term.

7.2 **<u>Habitat Restoration and Enhancement on USACE Lands at Project Dams and Reservoirs:</u> The USACE will continue to use existing authorities and programs for land and water resource stewardship on the lands it administers at the 13 Willamette projects to carry out aquatic and riparian habitat projects to benefit**

terrestrial organisms and resident fish species, in ways that do not harm ESA-listed species. Additionally, the USACE may design projects on USACE lands to benefit ESA-listed anadromous species. These actions will be carried out consistent with the best management practices identified in the "SLOPES IV Restoration" (NMFS 2008f) or other applicable biological opinions.

Rationale/Effect of RPA 7.2: In section 3.5.1 of the Proposed Action in the Supplemental BA (USACE 2007a), the Action Agencies propose to continue on-site habitat management activities aimed primarily at resident fish and wildlife species that use the reservoirs and adjacent lands. NMFS includes this measure to ensure that continued on-site activities are reviewed and modified, if necessary, to avoid adverse effects on listed UWR Chinook salmon and UWR steelhead. Further, on-site habitat projects that benefit UWR Chinook salmon and UWR steelhead should be funded through this program.

NMFS cannot quantify the effect of this measure on listed fish or critical habitat because the measure does not specify the number of projects or magnitude of benefit that should be directed at listed anadromous species. Insufficient information is available to assess the value of these reservoirs for rearing juvenile salmon and steelhead, and thus NMFS cannot determine how much, if any, habitat restoration work is needed in the reservoirs and adjacent aquatic habitat. However, this measure will provide benefit to listed anadromous fish because it will ensure that there are adequate protections for listed salmonids when the Action Agencies are conducting projects that benefit other species.

7.3 <u>Large Wood Collected at Project Dams</u>: **During annual maintenance operations, the Action Agencies will collect large wood that accumulates at Project dams and make it available for habitat restoration projects above and below Project dams.**

Rationale/Effect of RPA 7.3: This new measure that is not addressed in the Proposed Action is aimed at restoring large wood transport past Project dams. The continuing effects of Project dams on interruption of large wood transport were discussed in detail in each of the major tributary Effects sections (Middle Fork Willamette Section 5.2.4, McKenzie Section 5.3.4, South Santiam Section 5.5.4, and North Santiam Section 5.6.4). Lack of large wood in downstream fish habitat continues to reduce available rearing and holding habitat for juvenile and adult UWR Chinook salmon and steelhead. This measure ensures that large wood that collects in the reservoirs will be made available for such projects.

The effect of this measure is generally positive for listed anadromous fish because it is a first step in the process of habitat restoration that provides large woody debris that is a benefit to the fish and habitat elements.

7.4 <u>Restoration of Habitat at Revetments</u>: **In coordination with the Services, the Action Agencies will undertake a comprehensive assessment of revetments placed or funded by the USACE Willamette River Bank Protection Program. The revetment assessment will be completed, including identifying sites with potential for**

modification, by December 31, 2010. The USACE will use applicable existing authorities and programs for funding habitat restoration identified in Table 9.7-2, as well as new programs that are applicable, to fund priority projects identified in this assessment.

Rationale/Effect of RPA 7.4: This measure provides additional certainty to the Willamette River Bank Protection Program study described in section 3.5.4 of the Proposed Action (USACE 2007a). The Action Agencies indicated in that section that they had not identified funding sources or a timeline for conducting the study or follow-up actions. This RPA measure requires the USACE to secure funds for the study and complete it by December 31, 2010. Once completed, the Action Agencies would be required to seek funds to carry out projects at high priority sites.

The effect of this measure is that high priority sites for restoration or removal will be identified in the near term, and will be considered for funding through applicable authorities and programs. When projects are funded and carried out, the effect will be improved rearing and holding habitat, by opening access to off-channel rearing habitat and allowing establishment of complex habitat used for rearing and holding.

7.5 Aquatic Habitat Assessment: **By June 2008, the Action Agencies will complete surveys of spawning and holding habitat availability and condition in the major spawning tributaries with USACE dams (N. Santiam, S. Santiam, South Fork McKenzie, and Middle Fork Willamette rivers). The Action Agencies will distribute copies of the final report to the Services and will make the report available on the USACE's Portland District's website. Habitat survey data will also be available to the public in a GIS format. The Action Agencies will use the assessment to inform habitat restoration priorities for RPA measure 7.1.**

Rationale/Effect for RPA 7.5: The Action Agencies propose to complete this assessment by the end of FY 2008 (i.e., end of September 2008). These surveys will provide essential information for decision-makers regarding the availability of suitable habitat above and below Project dams for UWR Chinook salmon and steelhead.

9.8 ESA Compliance & Coordination

These measures are based on similar Proposed Action measures in section 3.6.5 of the Supplemental BA (USACE 2007a). Additionally, the coordination process described in these measures is encompassed within RPA measure 1, Coordination, of this Chapter 9. However, the following measures add specificity to those measures with regard to design review and construction implementation. Specificity is necessary to ensure that needed reviews will happen and that construction will be accomplished in a way that minimizes impacts on listed fish.

RPA 8 ESA Compliance, Maintenance, and Construction Projects Environmental Coordination and Management

8.1 **<u>Review of Design and Construction Reports</u>: The Action Agencies will collaborate with the Services on the design, construction and operation of all potential structural modifications to the dams and associated facilities, including fish collection and handling facilities, fish passage improvements, and water temperature control facilities. The Action Agencies will obtain the Services' review[45] of design reports and will address their recommendations in subsequent design reports. The Action Agencies will provide final design reports and drawings to the Services at least 30 days in advance of making the final design decision to allow time for their review and comment.**

Rationale/Effect of RPA 8.1: This measure is needed to ensure constructive collaboration between the Services and the Action Agencies to ensure facilities will be designed and constructed to be as benign to fish as possible. This review will take place as part of one of the technical subcommittee of the WATER group, as described in measure 1.2, and that decisions will be made according to the processes described in measures 1.3 and 1.4.

The effect of this measure is that facilities will be designed and constructed to minimize injury, mortality, and delay of listed fish, resulting in improved abundance and productivity, and in certain cases such as for fish passage facilities, increased spatial distribution of UWR Chinook salmon and steelhead.

8.2 **<u>Construction Practices</u>: Construction and operation will be carried out according to Best Management Practices (BMPs) and design specifications agreed[46] to by the Services. The Action Agencies will follow BMPs provided in Section 12, Incidental Take Statement. If these are updated, the Services will provide the updates to the Action Agencies, and the Action Agencies should follow the updated BMPs.**

Rationale/Effect of RPA 8.2: This measure builds on the Action Agencies' Proposed Action in section 3.6.5 of the Supplemental BA (USACE 2007a), in which the Action Agencies agreed to adopt and follow BMPs for construction of all potential structural modifications to the dams and associated facilities. In their Proposed Action, the Action Agencies agreed to use the BMPs outlined in NMFS' Biological Opinion concerning construction of the Cougar adult fish collection facilities (NMFS 2007a) as a starting point, and proposed to use a technical subcommittee of the WATER group to further refine BMPs. NMFS provides this modified measure to require BMPs consistent with those identified in the Incidental Take Statement for this Opinion, included as chapter 11. Additionally, NMFS broadens the action to apply to all construction activities that may include in-water work or affect fish or fish habitat, rather than only for fish facility construction.

The effect of this measure is that construction projects carried out as part of the Proposed Action, including continued Project operation and maintenance, revetment maintenance,

[45] See RPA 1.3 and 1.4 for elaboration of the decision making process.
[46] See RPA 1.3 and 1.4 for elaboration of the decision making process.

and fish and wildlife mitigation measures, will be done in a manner that minimizes harm to listed fish and avoid negative effects to critical habitat.

9.9 RESEARCH, MONITORING & EVALUATION (RM&E)

In their Proposed Action, the Action Agencies identify the need for developing a comprehensive research, monitoring, and evaluation (RM&E) program that will provide information necessary for making informed adaptive management decisions, in addition to tracking and documenting progress toward achievement of these RPA measures. They further identify the practicality of developing and managing this RM&E program under the auspices of the cooperative WATER subcommittee structure.

The Action Agencies provide certain guiding principles and strategic questions for consideration in developing a sound RM&E program. They also provide areas of concern where RM&E studies are needed. However, they generally do not make specific study recommendations.

The following RPA measures combine with portions of the PA and RPA measures described above to identify the broad outlines of an adaptive RM&E program. A comprehensive RM&E program is essential to guiding Action Agencies' decisions in carrying out PA and RPA measures and that will affect productivity, abundance, spatial distribution, and genetic diversity of listed fish species. Additional and specific details of the RM&E program, study objectives, and methodologies will be developed and refined through the WATER process.

RPA 9 Research, Monitoring & Evaluation (RM&E)

9.1 <u>Comprehensive Program:</u> **The Action Agencies will, in consultation with the WATER RM&E subcommittee, established as a technical subcommittee as described in RPA measure 1.2, develop and manage the comprehensive Willamette Project RM&E program. In developing and conducting the RM&E studies, the Action Agencies will work closely with the Services to ensure that the studies will provide information useful to the Services and the Action Agencies in making decisions regarding the effectiveness of mitigation measures in the Proposed Action and the RPA, including alternatives for downstream flows and ramping, fish passage, water quality, hatchery program operations, habitat restoration and other measures. The Action Agencies will seek NMFS' review of draft study proposals and draft reports. Comments submitted by NMFS on draft evaluation proposals must be reconciled by the Action Agencies in writing to NMFS' satisfaction prior to initiating any research-related activities anticipated in this RPA.[47] The proposals must identify annual anticipated incidental take levels by species, life stage, and origin[48] for each year. The Services will inform the Action Agencies whether they agree[49] with the proposed studies, reports, and NEPA alternatives. The Action**

[47] See RPA 1.3 & 1.4 for elaboration of decision making process.
[48] That is, hatchery-origin or non-hatchery origin fish.
[49] See RPA 1.3 & 1.4 for elaboration of decision making process.

Agencies will make modifications to operations and facilities based on the results of the RM&E information.

Rationale/Effect of RPA 9.1: Research, monitoring, and evaluation studies comprise an essential and important component of the protective measures identified within the RPA. Often lacking within the basin is detailed information regarding geographically-specific environmental conditions (e.g., quantity and distribution of functional spawning and rearing habitat) and the extent to which ongoing Willamette Project operations are continuing to affect those conditions (e.g., flow variation and duration in relation to sediment transport dynamics, channel and habitat complexity, and related juvenile fish behavior and survival). In other instances, problems attributable to Willamette Project dams and operations (e.g., migration barriers and water temperature alteration) require additional information to assess the most prudent and effective means of overcoming these important limiting factors. Consequently, the functional effectiveness of RPA measures often depends upon the ability to make informed and timely decisions regarding the most effective and practical means of achieving protection and restoration objectives associated with each of the listed species. In studies aimed at obtaining this information, and in documenting tangible progress toward achieving protection and restoration objectives, the Services must discern whether the proposed studies are designed and conducted in a manner that is in keeping with the original intent of the RPA measures. They must also assure that the results of these studies are effectively applied.

Other kinds of RM&E include monitoring the existing and new mitigation measures. This is necessary to ensure that the measures are functioning properly and continue to do so. Also, the RM&E information can be the basis for making modifications to make them function effectively.

The effect of this measure is that the Action Agencies will have a basis for informed decisions about new mitigation measures, and will be able to ensure that current and new measures will be effective, and can modify them as needed.

9.2 **Mainstem Flow, Tributary Flow, and Ramping RM&E: The Action Agencies will develop and carry out RM&E to determine compliance with, and effectiveness of, flow and ramping measures and to better discern and evaluate the relationships between flow management operations and the resulting dynamics of ecosystem function and environmental conditions downstream of Willamette Project dams. Because flow releases and ramping rates are measures that can be implemented immediately, the Action Agencies should give high priority to studies to evaluate their effectiveness. The Action Agencies will begin flow and ramping rate studies by 2009. The Action Agencies will make modifications to Project operations and facilities that affect mainstem and tributary flows, ramping, and Reclamation water contract implementation, including RPA measures 2 and 3 listed above, no later than January 2011, as indicated by results of the monitoring and evaluation, and with NMFS' agreement.**

Rationale/Effect of RPA 9.2: The studies and monitoring of mainstem and tributary flow rates and of project ramping rate restrictions, as identified above in RPA2.10 (Flow-Related RM&E) of Section 9.2 (Flow Management), are necessary to acquire specific information about the functional relationship between rates of flow (e.g., flow stage), or change in flow, and resulting habitat conditions, fish behavior, and survival (e.g., winter steelhead spawning in the North and South Santiam rivers during spring; juvenile fish stranding during flow level changes). Information from physical habitat surveys and from hydrologic modeling will provide the data needed to make informed decisions regarding the adequacy and effectiveness of the mainstem and tributary flow measures.

The effect of this measure is that it will provide the basis for decisions on important mitigation measures, mainstem flow, tributary flows, and ramping rates that are adequate for listed fish protection. The measure includes interim measures for these flows and ramping, so it will help listed fish in the short term by improving their habitat downstream of the dams.

9.3 **Fish Passage RM&E: The Action Agencies will develop and carry out RM&E to determine the most effective and efficient means to accomplish safe fish passage at applicable Project dams. The studies will be used to determine 1) locations where it is feasible to re-establish self sustaining populations; 2) potential population size for each subbasin; 3) effectiveness of rebuilt trap-and-haul facilities; 4) downstream fish passage timing and survival through Project reservoirs; 5) downstream fish passage timing and survival through Project dams; 6) operational methods for higher juvenile and adult survival at Project facilities; 7) infrastructure needs to ensure long term viability of populations; and 8) selection of hatchery or natural-origin broodstock, as well as life stage, for release into habitat above Project dams.**

These facilities must meet performance standards consistent with NMFS' Fish Passage Criteria and Guidelines (NMFS 2008e) or as determined through the FPHM committee of WATER and agreed to by the Services. The Action Agencies will monitor the effectiveness of the fish passage facilities. The Action Agencies will make modifications to Project operations and facilities that affect fish passage, including RPA 4 measures listed above, as indicated by results of the monitoring and evaluation, and with NMFS' agreement.

Rationale/Effect of RPA 9.3: Most historical production areas for UWR Chinook salmon and for UWR steelhead lie above federal dams in the Willamette River Basin. In general, the quality of the remaining habitat in these areas (e.g., on U.S. Forest Service lands) is also superior to that of the available habitat remaining below the dams. Re-accessing this habitat is a fundamentally important component of the strategy for protecting and restoring these listed species. Downstream fish passage through reservoirs and dams is influenced by unique characteristics at each site, such as dam configuration, reservoir length and depth, and life stage and physiological state of fish as they move downstream. In other words, what works at one project may not work at another, and thus, a study regarding the most effective and feasible means of re-accessing this habitat is essential.

This measure is needed to ensure that once passage facilities or operations are implemented at a Project dam, monitoring will take place to determine if facilities are performing as intended. If the facilities are not providing safe and effective passage, then they need to be modified accordingly. Performance standards are necessary to provide a quantitative measure of effectiveness.

The effect of this measure is to provide information to make decisions on passage measures that are one of the most important kinds of mitigation for project effects. It will also ensure that passage is working effectively.

9.4 **Water Quality RM&E: The Action Agencies will develop and carry out RM&E to monitor the effectiveness of measures in the RPA and Proposed Action to improve water quality, including but not limited to: 1) monitor operational performance and associated biological response of water temperature control in the McKenzie River Subbasin at Cougar Dam; 1a) quantify effects of USACE dams on water temperature; 2) evaluate biological effects of water temperature alteration caused by USACE dams on ESA listed fish species in the Santiam and Middle Fork Willamette rivers; 2a) quantify the effects of USACE dissolved gas and turbidity; 3) evaluate the effects of dissolved gas supersaturation and of turbidity alterations caused by USACE dams on ESA listed fish species in the Santiam, McKenzie, and Middle Fork Willamette rivers; and 4) conduct an aquatic macroinvertebrate species abundance and community structure study at USACE projects on the Santiam, McKenzie, and Middle Fork Willamette rivers to discern the extent to which project operations affect macroinvertebrate community composition, structure, and function. The Action Agencies will make modifications to Project operations and facilities that affect water quality, including RPA measure 5 (and its sub-measures) listed above as indicated by results of the monitoring and evaluation, and with NMFS' agreement.**

Rationale/Effect of RPA 9.4: It is well documented that Willamette Basin projects have dramatically affected water temperatures below federal dams, and also affect other important water quality parameters, to the detriment of listed species. These studies are necessary to document geographically-specific effects, their relevance to protection and the water quality RPA measures 5, and the tangible options for addressing these concerns.

9.5 **Hatchery Programs RM&E: The Action Agencies will develop and carry out RM&E to monitor the effectiveness of hatchery measures in the RPA and Proposed Action to improve hatchery effectiveness and reduce adverse effects to listed fish species, including but not limited to the following:**

9.5.1 **Spring Chinook**

1. **Broodstock Management- Determine collection and spawning timing of broodstock, composition of hatchery and wild fish.**

2. **Composition of Hatchery Fish on the Spawning Grounds- Determine the abundance, distribution, and percent hatchery-origin Chinook on the spawning grounds of each population annually.**
3. **Survival of Adult Hatchery Fish Outplanted above Federal Dams- Determine the survival rate of outplanted fish and abundance of spawners above the dams.**
4. **Reproductive Success of Hatchery Fish in the Wild- Determine juvenile production by hatchery and wild spawners above the dams.**
5. **Use of Hatchery Fish to Evaluate Migration and Survival through Reservoirs and Dams- As hatchery program reforms are implemented to make hatchery fish more similar to wild fish, use hatchery fish as a surrogate for wild fish in the testing and evaluation of migration, behavior, and survival of fish through the reservoirs and dams. Wild fish may be used in the future if risks are deemed acceptable.**

9.5.2 Summer Steelhead

1. **Fund, design, and implement a study plan, in collaboration with ODFW, to determine the extent of summer steelhead reproduction in the wild. Collect tissue samples from juvenile steelhead for genetic analysis to determine if offspring are of winter- or summer-run origin. Sampling shall begin in 2009. Details to be worked out by the Research, Monitoring, and Evaluation Committee.**
2. **Fund and conduct a spawning survey for three years (i.e. 2010-2012) to determine the extent of summer steelhead spawning in the North Santiam River Basin. Survey shall be initiated after the reduction of the North Santiam hatchery summer steelhead release is implemented.**

Rationale/Effect of RPA 9.5: The RM&E tasks identified above for the hatchery programs are essential in order to evaluate the effects of hatchery fish spawning in the wild and to determine how many natural-origin fish are being taken for broodstock. Information on both of these attributes helps inform and guide future management decisions on these hatchery programs and helps determine the status of listed populations. In addition, the Chinook hatchery programs are being used in many cases to reintroduce Chinook back into historical habitats above Project dams, thus it is necessary to evaluate the success of these outplanting programs.

9.6 Habitat Restoration RM&E: **The Action Agencies will develop and carry out RM&E for habitat restoration projects identified in the Proposed Action and this RPA to document changes in ecosystem function and biological response. The Action Agencies will make modifications to Project-related habitat restoration activities and structures, including RPA 7 measures listed above, as indicated by the results of the monitoring and evaluation and with NMFS' agreement.**

Rationale/Effect of RPA 9.6: The functional relationship between the characteristics and dynamics of habitat and related biological responses is poorly understood, in general. This is due, in part, to the complexity of those relationships and, in part, to the failure of restoration efforts to document their resulting biological effects. Careful planning of projects, with stated assumptions and objectives, in combination with post-construction physical and biological monitoring is required to document that intended benefits are realized. The information gained from this endeavor will provide the documentation required to make informed and adaptive management and planning decisions.

9.10 MAINTENANCE

These maintenance RPA measures are based on similar measures[50] described in the Proposed Action and apply to any constructed or fabricated features whose failure or improper function might affect ESA-listed fish and fish habitat such as, but not limited to, dams, gates, valves, pumps, access roads, fish hauling trucks, electrical power transmission grids, signal, control devices, and fish facilities.

These measures do not apply to the following:

- riverine components of the Willamette Project such as revetments, riprap, or riparian habitat improvements,
- re-configuration or rebuilding[51] of existing facilities (until they are placed in service.),
- items that are not likely to affect fish, such as building renovations, campground maintenance, recreational facilities, and
- preventative or routine maintenance.

The following measures add specificity to those maintenance measures in the Proposed Action:

RPA 10 Maintenance

10.1 **<u>Identify fish protection maintenance needs</u>. The USACE will develop and maintain a list of scheduled and unscheduled maintenance needs of existing infrastructure that could potentially negatively impact listed fish and will place high priority on maintaining performance of all such facilities. The scope of maintenance activities included encompasses all USACE dams, facilities, and appurtenances that *may significantly and adversely affect listed fish*, and includes not only "fisheries" facilities such as fish traps but all facilities required to meet the operations described in this Opinion (e.g. because forced spill can adversely affect downstream water quality, items such as turbines and generators may fall within this purview). This measure also affects those hatcheries raising listed fish, and all related hatchery facilities, including fish hauling trucks and related equipment used in fish transfers.**

The timeline for database modification and data entry:

[50] USACE 2007a including, but not limited to, pages 3-5, 6, 17, 18, 40, 41, 53, 54, 55, 56, 59, 68, 69, 71, 79-81, 91,136,137.

[51] Defined as measures costing more than 25% of the replacement cost of the existing structure.

1) All <u>new</u> items entered after 2008 shall include information noting whether they *may significantly and adversely affect listed fish,*[52]

2) All items, both new and pre-existing, shall be so notated by and after 2015[53].

Rationale/Effect of RPA 10.1: This RPA measure clarifies and makes uniform the maintenance reporting requirements for fish protection at all Project elements. USACE has a comprehensive maintenance program, including an associated database of maintenance needs. This RPA measure will enhance the USACE's database by associating with each discrepancy or defect noted in the maintenance database whether the needed maintenance *may significantly and adversely affect listed fish.* This measure is needed to ensure that all facilities that might affect listed fish—not merely fish facilities—will be maintained to minimize adverse effects to listed fish and fish habitat caused by equipment malfunctions.

The effect of this measure is to clarify that <u>all</u> facilities will be maintained to minimize injury, mortality, and delay of listed fish and destruction of fish habitat, resulting in improved abundance and productivity, and in certain cases such as for fish passage facilities, increased spatial distribution of UWR Chinook salmon and steelhead.

10.2 **<u>Inventory of Needed Maintenance</u>: The USACE will provide the maintenance report described in the Proposed Action (USACE 2007a, p. 3-18 Item 2 in Section 3.2.2[54]) in electronic[55] database format to NMFS by February 1, 2009, and thereafter whenever requested in writing by NMFS. This report will include an inventory of current major deficiencies, (i.e., where facilities are in need of maintenance or replacement) and the anticipated date of correction, and for those previously identified maintenance items that have been corrected, the report will identify the date the deficiencies were corrected. To aid in the identification of repeated problems, all corrected deficiencies will be retained in the database.**

Rationale/Effect of RPA10.2: This measure builds on the Action Agencies' commitment to maintain project facilities included in the Proposed Action. The Action Agencies commit "to describe scheduled and unscheduled" maintenance, but do not commit to reporting or inventorying discovered discrepancies, or their correction. The effect of this measure will be to ensure that the Action Agencies will maintain an orderly and systematic record of maintenance deficiencies and problems that might affect listed fish and a record of when these deficiencies are corrected. Ultimately, in conjunction with the measure below, this will assist in minimizing harm to listed fish and avoiding degradation of designated critical habitat.

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[52] That is, this is not an immediate requirement to go through the existing database—at least for five years-- to determine whether the items in the existing backlog *may significantly and adversely affect listed fish.*

[53] The intent here is to avoid an immediate requirement to research each of reportedly 30,000 items in the existing maintenance database for their impact on fish. During this five-year period any new deficiencies entered into the database will be annotated with respect to their possibility to affect fish. Presumably, many of the currently existing deficiencies will have been corrected within 5 years, so at the end of this period the task of assessing remaining deficiencies will not be great.

[54] Now within the Willamette Fish Operations and Management Plan--WFOP

[55] MS Access format or other mutually agreed upon format.

10.3 **<u>Perform Timely Maintenance</u>: The Action Agencies will correct the items noted in the inventories identified in RPA measures 10.1 and 10.2 above in a timely manner. All identified maintenance needs will be corrected, subject to congressional appropriation, or unless otherwise concurred with by NMFS. Notwithstanding, the USACE will correct deficiencies likely to cause substantial fish injury, mortality, or habitat degradation as soon as reasonably possible after discovery. The determination of whether injury, mortality, or loss of habitat function will occur in any particular instance will be collaboratively determined by NMFS and the Action Agencies.**

***Rationale/Effect of RPA 10.3*:** The Action Agencies have committed "to describe scheduled and unscheduled" maintenance (USACE 2007a), but have not actually committed to a timeline for correcting maintenance discrepancies.

The effect of this measure will be to minimize the likelihood of mortality and injury of adult and juvenile UWR Chinook and steelhead associated with malfunctioning equipment, unscheduled shutdowns, toxic substances, and other consequences of maintenance discrepancies. Additionally, this measure will reduce the likelihood of degradation of designated critical habitat for UWR Chinook and steelhead caused by malfunctioning equipment and other consequences of maintenance discrepancies.

9.11 Conclusion: Effects of the Reasonable & Prudent Alternative

This section presents NMFS' rationale for concluding that with the adoption of this RPA, the Action Agencies would avoid jeopardizing listed species and adversely modifying their critical habitats while operating and maintaining Project facilities and revetments, funding the hatchery mitigation program, and administering the water service program. This rationale is presented for the species that NMFS concluded would be jeopardized by the proposed action (UWR Chinook salmon and UWR steelhead) and for the other species that would be affected by the RPA.

The Proposed Action would jeopardize the continued existence of UWR Chinook salmon and UWR steelhead, and would destroy or adversely modify critical habitat because it did not adequately address adverse effects of the dams, revetments and hatcheries on listed fish, factors that are suppressing the viability of both species and are contributing to the high risk of extinction for UWR Chinook.[56] NMFS' RPA provides a package of measures that will allow for the survival with an adequate potential for recovery for these two species. The main negative effects of the Proposed Action are lack of effective passage to important habitat, degradation of remaining habitat, adverse flows and temperature, and hatchery actions that have the potential to reduce the viability of the natural-origin populations. The RPA provides specific measures that will address project effects by improving the status of natural-origin UWR Chinook salmon and UWR steelhead. The RPA measures will improve spatial distribution (habitat access; geographic range), diversity (hatchery broodstock management), productivity (improved conditions below the dams), and abundance (reduced mortality rates), which are the four VSP parameters.

[56] The WLCTRT (McElhany et al. 2007) estimated the risk of extinction over 100 years for UWR Chinook ("high;" see Figure 3-5 in Section 3.2.1.3). The TRT did not estimate the species' short-term extinction risk.

Improvements in these four VSP parameters will increase viability and reduce the risk of extinction to the affected populations and to the UWR Chinook salmon ESU and UWR steelhead DPS as at the species level. The RPA provides increased certainty that Proposed Action measures intended to benefit listed species will be accomplished within reasonable time periods to prevent extinction in the short term and to support improvements in UWR Chinook salmon and UWR steelhead abundance. RPA measures also improve habitat PCEs, ensuring that critical habitat will be able to serve its conservation role.

9.11.1 UWR Chinook Salmon

9.11.1.1 Effects of the RPA

The RPA specifies many significant measures that will reduce the adverse effects of the Willamette Project on the UWR Chinook ESU and bring about the proper functioning of primary constituent elements (PCEs) of its critical habitat. Many of the RPA measures specifically address key limiting factors/threats facing each population and caused by the Willamette Project: lack of passage, the degraded quality of the remaining habitat downstream of the dams; and the risks of genetic introgression, competition, and predation from hatchery fish. Four core populations have been identified for this ESU (Middle Fork Willamette, McKenzie, South Santiam, and North Santiam; see Chapter 3), and each of these populations will benefit from major RPA measures in the form of access to historical habitat, and/or temperature control and flow measures within the first few years of implementation (Section 9.11.1.3.1). With full implementation of the RPA, NMFS expects that the status of the ESU, including the four VSP parameters, will improve significantly compared to their potential status under the Proposed Action.

As shown in Table 9.11-1, several major RPA measures will be completed between 2015 through 2024, including passage at dams in the Middle Fork and South Santiam, which will provide safe passage to and from historical upstream habitat, and temperature control to improve downstream habitat in the North Santiam. Most of these measures are major construction projects that take a significant amount of time to plan, fund, and execute. For a full description of the authorization and funding processes needed for these types of measures, see the Supplemental Biological Assessment (USACE 2007a). It is not economically and technically feasible to move the timelines for many of these measures forward significantly due to their magnitude and the time needed for studies, design, authorization and construction.

Given these constraints, the anticipated population status improvements will begin in the next 15 years and continue to increase over the 15-year term of this Opinion. It will take several generations of the Chinook life cycle to respond to the positive improvements in the operation of the Willamette Project and associated measures. Therefore, significant improvements in the status of the ESU will continue to accrue in the next 30 years (approximately six generations). While implementation of these RPA measures will occur during the term of this Opinion, their full effects on population metrics (e.g., abundance, productivity) will occur over a considerable period of time after implementation. Therefore, NMFS expects that substantial improvements to the ESU will result from the implementation of the Proposed Action and the RPA.

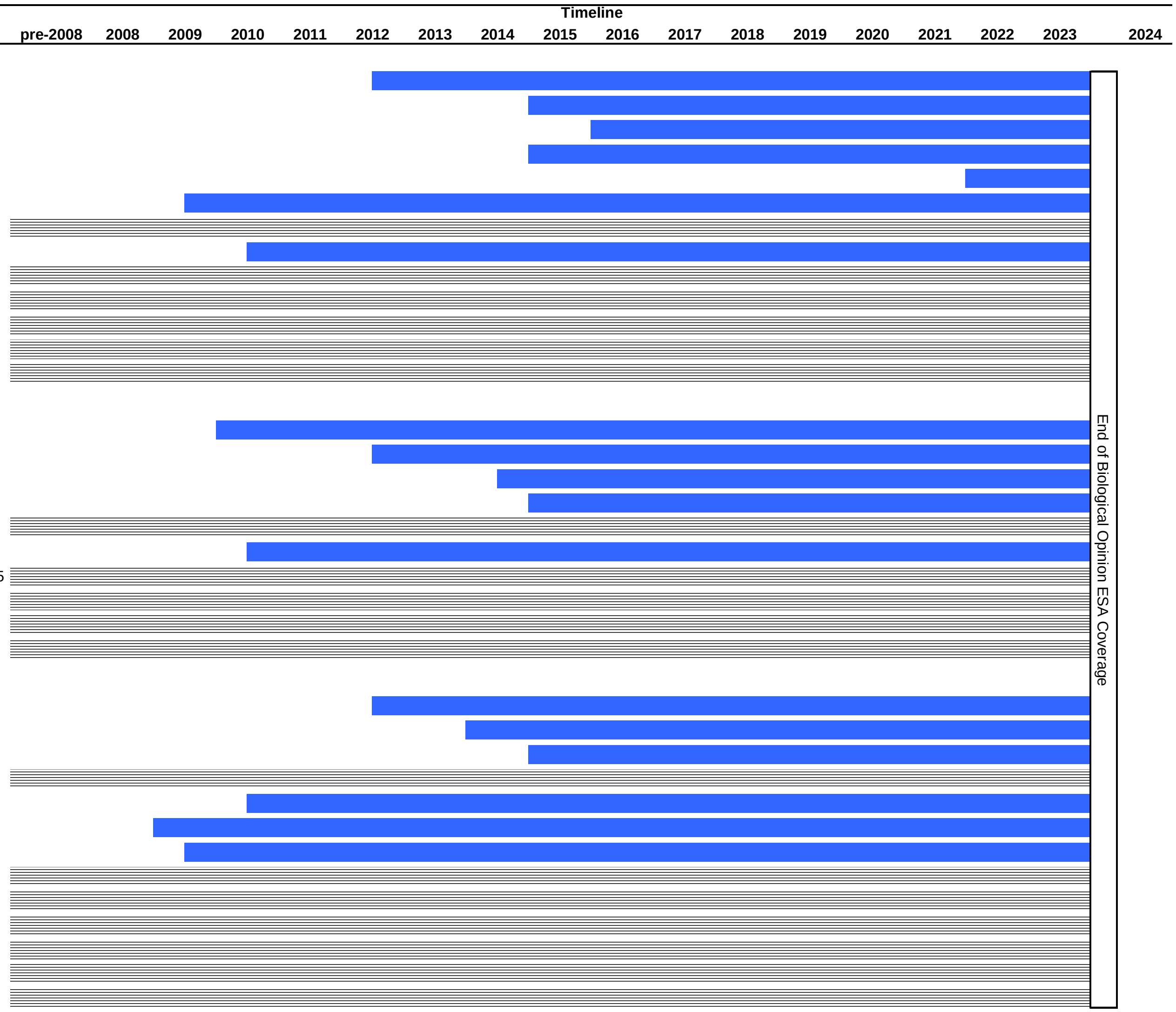
In addition to the major measures specified in Table 9.11-1, numerous other near-term measures such as changes to flow, screening irrigation diversions, hatchery program modifications, and habitat mitigation projects are included in the RPA. The "near-term" measures in Table 9.11-1 directly address project effects on listed fish and critical habitat without requiring as many years to plan and implement as the measures discussed above. A third group of measures, such as conducting RM&E studies, developing fish operations manuals, project planning, and implementing the WATER collaborative process, will begin in the near term. Although this third group of activities also has not been included in the summary table, these are essential tasks that will facilitate construction of the large structures as well as guide annual operations, all of which will benefit UWR Chinook.

Difference between the Proposed Action and RPA

The effect of the RPA measures on UWR Chinook is significantly different than the effect of the Proposed Action. The Proposed Action mainly provided for further studies to consider options such as passage facilities to historical upstream habitat, as well as a major downstream habitat improvement measure of temperature control. In addition, the RPA includes measures to improve degraded downstream habitat through changes to flows, screens at irrigation diversions, hatchery improvements, and other habitat improvement projects. These RPA measures are significant because UWR Chinook are currently limited to degraded downstream habitat in three important subbasins. The RPA measures both provide access to higher quality habitat and improve downstream habitat conditions, which together will provide significant enough improvements to allow the UWR Chinook ESU to increase in numbers, productivity, spatial structure, and diversity.

Table 9.11-1 Date of implementation of the RPA measures that will directly benefit UWR Chinook salmon and steelhead and their habitat.

Geographic Area	RPA #
Middle Fork Willamette	
Adult outplant site(s)	4.7
Dexter collection facility rebuild	4.6.3
Fall Creek collection facility rebuild	4.6.4
Juvenile prototype (here or Green Peter (SS))	4.9
Lookout Point downstream facility	4.12.2
Interim temperature control (actions unspecified)	5.1.2
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Chinook outplanting above dams	4.1
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Fall Creek reservoir drawdown	4.8.1
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1
McKenzie	
Cougar collection facility	
Adult outplant site(s)	4.7
Leaburg hatchery sorting	6.1.4
Cougar downstream facility	4.12.1
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Chinook outplanting above dams	4.1, 6.1.5
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1
South Santiam	
Adult outplant site(s)	4.7
Foster collection facility rebuild	4.6.2
Juvenile prototype (here or Lookout Pt (MFW))	4.9
Water contract program	9.3
BOR compliance with fish protection criteria	3.2
Reduce hatchery steelhead residualism	6.1.6
Reduce hatchery steelhead recycling	6.1.7
Chinook outplanting above Foster Dam	4.1
Winter steelhead outplanting above Foster Dam	4.2
Project-specific ramping rates	2.6
Project-specific min & max flows	2.4, 2.5
Foster reservoir spring spill operations	2.7
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1



Grey lined bar: ongoing, continuing measures that have been in effect prior to the completion of this Biological Opinion

Blue bar: new measures that will be taken in the future (after this Biological Opinion is completed)

* This chart summarizes only a portion of the measures analyzed in this Opinion. Numerous other planning processes other planning processes, operational protocols and guidelines, research monitoring and evaluation, emergency operation plans are not included here.

Table continued on next page.

Table 9.11-1. ***(Continued)***

Geographic Area	RPA #	pre-2008	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023		2024
Calapooia																				
No RPA actions identified in this geographic area.																				
North Santiam																				
Adult outplant site(s)	4.7																			
Minto collection facility rebuild	4.6.1																			
Detroit Water Temperature Facility	5.2																			
Interim temperature control	5.1.1																			
Detroit downstream facility	4.12.3																			
Water contract program	9.3																			
BOR compliance with fish protection criteria	3.2																		End of Biological Opinion ESA Coverage	
Reduce hatchery steelhead production	6.1.8																			
Reduce hatchery steelhead residualism	6.1.6																			
Reduce hatchery steelhead recycling	6.1.7																			
Chinook outplanting above dams	4.1																			
Project-specific ramping rates	2.6																			
Project-specific min & max flows	2.4, 2.5																			
Hatchery and Genetic Mgmt Plans (HGMPs)	6.1.1																			
Molalla																				
Hatchery Chinook reform	6.2.5	No date specified.																		
Hatchery and Genetic Mgmt Plan (HGMP)	6.1.1																			
Clackamas																				
No RPA actions identified in this geographic area.																				
Mainstem Willamette River																				
Mainstem flow targets	2.3																			
Habitat restoration projects					Two projects will be funded in 2010. Others unspecified.															
Water contract program	9.3																			
BOR compliance with fish protection criteria	3.2																			

(Column header "Timeline" spans the year columns.)

ongoing, continuing measures that have been in effect prior to the completion of this Biological Opinion

new measures that will be taken in the future (after this Biological Opinion is completed)

* This chart summarizes only a portion of the measures analyzed in this Opinion. Numerous other planning processes other planning processes, operational protocols and guidelines, research monitoring and evaluation, emergency operation plans are not included here.

9.11.1.2 UWR Chinook Populations—Summary of Effects of the RPA

The following is a population-by-population summary of the effects of the RPA. The RPA and the analysis in this section specifically address short-falls in the effects of the Proposed Action, which are identified in earlier sections of this Opinion (see especially Chapter 7, "Summary of Effects of the Proposed Action on UWR Chinook and Steelhead.")

Middle Fork Willamette Chinook

The primary reason for the poor status of the Middle Fork Willamette Chinook population (very high risk of extinction) is the loss of access to historical habitat due to the four Willamette Project dams and elevated temperatures in the reach below Dexter Dam and in lower Fall Creek. The risk of genetic introgression from hatchery-origin fish interbreeding with those of natural origin is also a key limiting factor.

- The RPA will improve upstream passage survival by rebuilding the collection facilities at Dexter and Fall Creek dams to reduce stress, injury, and mortality during capture and handling of Chinook salmon for outplanting (safe passage) above Project dams.
- *RPA 4.6: complete construction at Dexter by December 2014 and begin operations by March 2015; complete construction at Fall Creek by December 2015 and begin operations by March 2016*
- Construction and operation of new adult release sites above Lookout Point, Hills Creek, and Fall Creek dams will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.
- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- A downstream passage facility at Lookout Point reservoir/dam will allow higher survival of juvenile Chinook emigrants resulting from the adult outplanting program.
- *RPA 4.9: build prototype for head-of-reservoir juvenile collection facility at Lookout Point or Foster by 2014*
- *RPA 4.12.2: develop permanent downstream passage facility at Lookout Point—begin feasibility studies by 2012, construct by December 2021, and operate by March 2022 (if not feasible, make "no go" decision by end of 2014)*
- Drawdown to at least elevation 714.0 by the end of November each year will optimize downstream passage conditions at Fall Creek Dam during the juvenile outmigration.
- *RPA 4.8.1: reduce head by implementing Fall Creek drawdown beginning in Water Year 2008 (Nov-Jan, except during flood control operations), reducing injury and mortality of Chinook smolts*
- Interim operational measures at Lookout Point, Hills Creek, and Fall Creek dams will restore normative seasonal water temperatures.
- *RPA 5.1.2: Identify interim measures by March 2010*

- *RPA 5.1.3: Evaluate more complex measures (requiring detailed environmental review, permits, and/or congressional authorization) by April 2011*

- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns below dams, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 4.6: improve fish collection facility at Dexter Ponds (begin construction by December 2014 and begin operations by March 2015) and at Fall Creek Dam (begin construction by December 2015 and begin operations by March 2016).*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark, and insert coded wire tags into all hatchery Chinook prior to release*

- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

The combined effect of these measures (especially the mechanisms for efficient sorting of hatchery fish for broodstock and to augment spawning above Dexter and Fall Creek dams, improvements in downstream passage survival in the Middle Fork Willamette and Fall Creek and in water temperatures in the Middle Fork) are expected to significantly improve the status of the Middle Fork Willamette population. Chinook will have access to high quality historical spawning and rearing habitat above the dams and the opportunity for successful spawning, incubation, and rearing in the lower reaches. Resulting juvenile production will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these

[57] Habitat restoration projects may be distributed in the lower reaches of the tributaries with spawning populations and in the mainstem Willamette.

measures become operational. These actions will improve the function of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.6; 4.7; 4.8.1; 4.9; 4.12.2; and 7.1.3).

McKenzie Chinook

The McKenzie Chinook population is at moderate risk of extinction. The risk of genetic introgression by hatchery fish and the loss of historical habitat due to blockage by Cougar Dam on the South Fork McKenzie River are two of the key limiting factors identified for this population. Under the Proposed Action, a new adult collection facility, to be completed by 2010, will allow fish to be collected and transported above Cougar Dam, restoring access to this high quality habitat with reduced rates of stress, injury, and mortality. In addition:

- The RPA will significantly reduce the risk of genetic introgression and competition by hatchery fish in the natural population by limiting hatchery fish straying above Leaburg Dam in the lower McKenzie River.

- *RPA 6.1.4: complete construction of the adult trap and sorting facility at Leaburg Dam by December 2013 and begin operations by spring 2014.*

- Construction and operation of an adult release site above Cougar Dam will increase upstream passage survival and reduce pre-spawning mortality by minimizing the stress and injury of adult Chinook salmon outplanted above the dam.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- A downstream fish passage facility will be constructed at Cougar Dam to improve juvenile Chinook outmigrant survival

- *RPA 4.12.1: Initiate planning and make "go/no go" decision by end of 2010; complete construction by 2014, begin operations by 2015*

- The RPA will address the effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flows, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

• Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

• Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*
- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially the mechanism for efficient removal of hatchery fish from the spawning population above Leaburg Dam, implementation of hatchery reforms per HGMPs, flow management, and improvements in upstream and downstream passage survival at Cougar Dam), are expected to significantly improve the status of the McKenzie River population. Natural-origin Chinook will have access to high quality historical spawning and rearing habitat above Cougar and the opportunity for successful spawning, incubation, and rearing. Juveniles produced above Cougar will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.12.1; 6.1.4; and 7.1.3).

Calapooia Chinook

The risk of genetic introgression by hatchery fish interbreeding with those of natural origin and impaired physical habitat from past and/or present land uses are key limiting factors for the Calapooia population, which is at very high risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*
- Adverse effects of the Chinook hatchery program will be minimized.
- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*

Implementation of the hatchery measures will increase the genetic diversity of Chinook spawning in the Calapooia River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located within the Calapooia subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Calapooia subbasin.

South Santiam Chinook

The loss of access to historical habitat above Foster and Green Peter dams and the risk of genetic introgression by hatchery fish interbreeding with those of natural origin, especially in the lower South Santiam below Foster Dam, are key limiting factors for this population, which is at very high risk of extinction.

- The RPA requires rebuilding of the collection facility at the base of Foster Dam to allow better capture and handling of Chinook for outplanting into historically accessible habitat above the dam.
- *RPA 4.6: complete construction of the new adult collection and handling facilities at Foster Dam by December 2013 and begin operations by March 2014.*
- Construction and operation of new adult release sites above Foster Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.
- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- The RPA addresses the long-term need to improve reservoir and dam passage survival at Foster Dam for juvenile Chinook throughout the juvenile migration period.

- *RPA 4.13: The Action Agencies will evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs, including Foster, in their development of the Willamette Configuration and Operation Plan (COP). This will include facilities and operations that require detailed study including feasibility studies and environmental permitting such as long-term fish passage solutions at Foster Dam.*

- Interim operational measures at Green Peter and Foster dams will help to restore more normative seasonal water temperatures

- *RPA 5.1: Identify interim measures by March 2010*

- *RPA 5.1.3: Evaluate more complex measures (required detailed environmental review, permits, and/or congressional authorization) by April 2011*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.2 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*

- *RPA 4.6: improve fish collection facility at Foster Dam (begin construction by December 2013 and begin operations by March 2014).*

- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark, and insert coded wire tags into all hatchery Chinook prior to release*

- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially the mechanism for efficient removal of hatchery fish from the spawning population above Foster Dam, implementation of hatchery reforms per HGMPs, flow management, and improvements in downstream passage survival at Foster Dam) are expected to significantly improve the status of the South Santiam population. Natural-origin Chinook will have the opportunity for successful spawning, incubation, and rearing in the reach above Foster and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.6; 4.7; 4.13; and 7.1.3).

North Santiam Chinook

The loss of access to historical habitat above Big Cliff and Detroit dams, poor natural production below the dams, and the risk of genetic introgression by hatchery fish interbreeding with those of natural origin are key limiting factors for this population, which is at very high risk of extinction.

- The RPA provides measures that will improve upstream passage survival by building a new adult collection facility to replace the trap at the Minto barrier dam, allowing the capture and handling of Chinook for outplanting above Big Cliff/Detroit dams with reduced levels of stress, injury, and mortality.

- *RPA 4.6: complete construction of the new adult collection and handling facilities in North Santiam by December 2012 and begin operations by March 2013.*

- Construction and operation of new adult release sites above Detroit Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- Downstream passage improvements at Detroit Dam and Reservoir will increase juvenile Chinook survival and increase the number of smolts emigrating from the population. Combined with RPA 4.6, above, this measure is expected to increase the abundance, productivity, and spatial structure of the North Santiam Chinook population.

- *RPA 4.12.3: initiate planning by 2015, make "go/no go" decision by end of 2017; complete construction by end 2023, begin operations by March 2024.*

- The RPA requires implementation of interim temperature control using existing facilities. This action will provide immediate survival benefits, significantly reducing the problem with the altered water temperature regime in natural production areas downstream of Detroit/Big Cliff dams until a Water Temperature Control facility or alternative solution is implemented. Normative water temperatures, particularly during the critical egg incubation period in late fall, will improve the abundance and productivity of the population.

- *RPA 5.1.1: identify and evaluate interim operational measures at Detroit Dam and, if feasible, begin implementation in Water Year 2009.*
- *RPA 5.2: make structural modifications or major operational changes at Detroit Dam for improved water quality, initiating planning by 2010, completing construction by December 2018, and beginning operations by March 2019.*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*
- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Screening diversions will remove impediments or barriers to juvenile Chinook migrants

- *RPAs 3.2 and 3.3: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 4.6: build new fish collection facility in the North Santiam (begin construction by December 2012 and begin operations by March 2013).*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*
- *RPA 6.2.4: cooperate with ODFW to release juvenile hatchery-origin Chinook that are more similar to natural-origin fish.*

These measures (especially implementation of hatchery reforms per HGMPs, providing safe upstream and downstream passage at Big Cliff/Detroit dams, flow management, and improvements in water temperature below Big Cliff Dam) are expected to significantly improve the status of the North Santiam population. Natural-origin Chinook will have the opportunity for successful spawning, incubation, and rearing in the reach above Detroit and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin Chinook as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.2; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 3.2; 3.3; 4.7; 4.12.3; and 7.1.3).

Molalla Chinook

Genetic introgression of an out-of-basin hatchery stock and impaired physical habitat for past and/or present land uses are key limiting factors for this population, which is at very high risk of extinction.

- The RPA will address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- The RPA will eliminate use of the current out-of-basin hatchery stock and replacement over time with a locally-derived broodstock. This hatchery reform action will promote local adaptation within the population.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*
- *RPA 6.2.5: support ODFW efforts to eliminate use of non-local Chinook stock and to develop locally-adapted broodstock.*

Implementation of the hatchery RPA measures will increase the genetic diversity of Chinook spawning in the Molalla River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located in the Molalla subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Molalla subbasin.

Clackamas Chinook

The risk of genetic introgression by hatchery fish interbreeding with those of natural origin and impaired physical habitat from past and/or present land uses are limiting factors for the Clackamas spring Chinook population, which is at moderate risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

- *RPA 7.1.3: implement at least tow habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Adverse effects of the Chinook hatchery program will be minimized.

- *RPAs 6.1.1 and 6.2.2: cooperate with ODFW in the implementation of HGMPs, which include management plans for building genetic diversity using local broodstocks.*
- *RPA 6.1.3: continue to mark all hatchery Chinook released in the Willamette Basin with adipose fin clip and otolith mark and insert coded wire tags into all hatchery Chinook prior to release.*

Implementation of the hatchery measures will increase the genetic diversity of Chinook spawning in the Clackamas River and will lead to increased abundance and productivity over time. Because the RPA does not require that habitat projects be located within the Clackamas subbasin, NMFS does not assume that this RPA measure will improve the status of this Chinook population or the functioning of PCEs in the Clackamas subbasin.

All UWR Chinook Populations

The following RPA actions, located or affecting conditions within the mainstem Willamette, will affect all populations of UWR Chinook salmon.

- RPA 2.3: obtain NMFS' approval before changing mainstem Willamette (Albany and Salem) flow objectives, to ensure that flow-related habitat needs of UWR Chinook for rearing and juvenile and adult migrations are fully considered.
- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows and the maintenance of revetments) on downstream habitat.

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.[57] Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Ensure that the availability of adequate water for fish and habitat protection in the tributaries and in the mainstem Willamette is not precluded by the water contract program

- *RPA 3: Reevaluate the availability of water from conservation storage for the water contract program and reinitiate consultation if future irrigation demands exceed 95,000 acre-feet.*

These actions will improve the functioning of PCEs in designated critical habitat:

- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (specifically RPA measures 2.3; 7.1.1; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.3; 7.1.1, and 7.1.3).

9.11.1.3 Conclusions—UWR Chinook Salmon

9.11.1.3.1 Jeopardy Analysis

The beneficial effects of the RPA (see above), which includes the Proposed Action (Chapters 5 and 7), combined with recent improvements in project facilities and operations (Chapter 4), is expected to address the harm to UWR Chinook caused by the Project. The RPA is designed to increase the abundance, productivity, spatial structure and diversity of the natural-origin Middle Fork Willamette, McKenzie, and South and North Santiam Chinook populations and to increase the genetic diversity of the Calapooia, Molalla, and Clackamas populations. The loss of access to historical habitat will be ameliorated by the rebuilding of fish collection facilities below Fall Creek, Dexter, Foster, and Big Cliff dams to allow significantly safer capture, handling, and transport of Chinook for release above the Project dams. Downstream passage facilities will be constructed for three populations (Middle Fork, McKenzie, and North Santiam) to provide significantly higher survival of emigrating Chinook than under either current operations or the Proposed Action. Interim and long-term water temperature control operations in the North Santiam River will improve altered water temperatures that have depressed natural production in the habitat below the dams. Hatchery reform actions will limit the risk of genetic introgression into the natural-origin populations, promoting life-history diversity and increasing the abundance and productivity of each population. Increases in the viability of these populations will contribute to increases in the status, lowering the risk of extinction, of the ESU as a whole.

Although the RPA measures combined with the Proposed Action will be implemented over the 15-year term of the Opinion and some of the biological benefits will take even longer to accrue, a number of measures will provide benefits in the short-term, reducing the ESU's short-term risk of extinction. Specifically, project operations have had a key role in degrading habitat conditions downstream, which in the North and South Santiam, South Fork McKenzie, and Middle Fork Willamette are the only areas accessible to Chinook for spawning, incubation, and early rearing. The Action Agencies began new reservoir operations in 2000 to meet mainstem and tributary flow objectives for listed fish. These, and operations that began in 2005 at the new Water Temperature Control facility at Cougar Dam, are already able to have a positive influence on adult returns. By spring of 2009, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and prespawning adults and thus population productivity. All of these measures will reduce extinction risk in the short-term as well as contributing to long-term viability. The Action Agencies will adapt their operations to new information on physical habitat properties, including those related to climate change, as the information becomes available over the next 15 years (Section 5.1.7).

The hatchery program for UWR Chinook acts as a safety net for most of the affected populations, reducing the short-term risk of extinction. Under the RPA and Proposed Action, the Action Agencies will cooperate with ODFW in continuing the transition from the historical supplementation programs to conservation/supplementation programs that focus on building genetic diversity using local broodstocks. As part of this effort, the Action Agencies will complete construction of a new sorting facility at Leaburg Dam by 2013. ODFW will use the new facility to prevent hatchery-origin Chinook from interbreeding with natural-origin fish above Leaburg. This will preserve the genetic diversity of fish in an important natural production area, another buffer against short-term extinction.

Reclamation will immediately improve its water contracting program. All (existing, new, and renewed) contracts will be subject to the availability of water, and when there is not enough water to meet minimum flow targets and irrigation contracts, instream flows will be preserved. All contracts will require that irrigation intakes and diversion dams be screened to preclude entrainment and all existing water diversions served by existing water contracts will be screened by April 1, 2010. The headgate requirement will ensure that water diversions can be stopped when not needed, or when directed by OWRD. Particularly during deficit water conditions, this reform will preserve instream flows for fish habitat needs.

The Action Agencies will continue to outplant adult UWR Chinook salmon above Detroit (North Santiam); Foster (South Santiam); Cougar (McKenzie); and Lookout Point, Hills Creek, and Fall Creek dams (Middle Fork Willamette population), an operation that enhances spatial structure in the short term while long-term passage facilities are developed. The outplanting program will be managed according to an annual Fish Operations Plan, coordinated with the Services and ODFW, which will address how, where, and when outplanted fish will be collected, held, marked, sampled, transported, and released, and will incorporate changes needed to further protect these fish based on research and monitoring.

The Action Agencies will also begin to upgrade existing adult fish collection and handling facilities in the first half of the term of the Opinion. Dates for beginning operations at the new facilities are March 2013 in the North Santiam, 2014 at Foster Dam (South Santiam), 2015 at Dexter Ponds, and 2016 at Fall Creek Dam (Middle Fork Willamette). Once construction is complete, adult fish will experience reduced levels of stress and injury, which is expected to lessen pre-spawning mortality. Completion of these facilities will also help ensure that broodstock targets are met.

The Action Agencies will design and begin to use new adult release sites above the dams by 2012. These new sites, like the improved adult collection facilities, will reduce stress and injury and thus the risk of prespawning mortality.

In addition to these measures, which will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the risk of extinction, the RPA requires that the Action Agencies complete various RM&E efforts, feasibility studies, and where needed, NEPA analysis. NMFS expects that these evaluations will lead to the construction of facilities and adjustments in operations during the second half of the term of this Opinion that will ensure that conditions are optimized for all affected life stages of UWR Chinook. These will include:

- Adjustments to mainstem and tributary flow objectives and ramping rates to meet the needs of the species over all affected life stages
- Operations for water quality (temperature and dissolved gas) and construction of new facilities
- Construction of additional juvenile passage facilities
- Full implementation of the habitat restoration program
- Adaptation of flow management and water quality measures to changing climatic conditions

The near- and longer-term RPA measures described above will address the effects of the Willamette Project that are detrimental to all life stages of UWR Chinook that occur within the

Willamette Basin: adult migration and holding, spawning and incubation, juvenile rearing, and emigration.

Other measures taken by the same Action Agencies under the environmental baseline (as required by the 2008 FCRPS RPA; NMFS 2008a) will improve the survival and condition of juvenile UWR Chinook in the lower Columbia River and estuary. The effects of the Willamette Project on habitat are very small in the lower Columbia and estuary, with slight to negligible adverse effects on viability (Section 5.11). However, the FCRPS RPA includes beneficial measures to reduce smolt predation by Caspian terns and Northern pikeminnows and a significant estuary habitat restoration program to ensure that biological requirements are met. These actions will benefit both yearling and subyearling Chinook from the Willamette Basin during the critical period prior to ocean entry.

After reviewing the effects of the RPA measures combined with the Proposed Action, which address significant adverse impacts of the Willamette Project (lack of effective passage, degraded water quality and physical habitat properties, and adverse effects of hatchery practices on population viability), the rangewide status of the species, the effects of the environmental baseline (UWR Chinook limited to significantly degraded habitat in several important subbasins), and cumulative effects (reasonably certain non-federal activities intended to benefit the status of the species mixed with those likely to have adverse effects), NMFS has determined that the UWR Chinook salmon ESU is expected to survive with an adequate potential for recovery. The actions that will be implemented in the first few years, including reforms to the Hatchery Mitigation Program, will protect the species against the short-term risk of extinction while longer-term measures are designed and constructed. NMFS therefore concludes that the RPA and Proposed Action, combined, are not likely to jeopardize the continued existence of the UWR Chinook salmon ESU.

9.11.1.3.2 Critical Habitat Analysis

The measures described in the RPA combined with the Proposed Action will also improve the functioning of primary constituent elements of habitat needed for the conservation of the species, restoring the ability of designated critical habitat affected by the Project to serve its conservation role. The actions described above will significantly improve the following PCEs over the term of the Opinion:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival

In the first one-to-seven years, the Action Agencies will rebuild the adult Chinook collection facilities and will build new release sites above Project dams. These measures will provide safe passage to high quality freshwater spawning sites with water quantity and quality and substrate that support spawning, incubation, and larval development. A new downstream passage facility at Cougar will also become operational during this period, further improving passage conditions for juvenile Chinook. Ongoing operations to meet flow objectives in the Middle Fork

Willamette, McKenzie, and South and North Santiam rivers, and operations that preserve instream flows during deficit water conditions will ensure adequate water quantity in spawning, rearing, and early migration areas. The Action Agencies will implement interim temperature control operations at Detroit Dam in the North Santiam to provide water quality needed for adult migration, spawning and incubation, and juvenile and kelt downstream survival. All existing water diversions will be screened by April 1, 2010, also contributing to safe passage in the juvenile migration corridor.

The actions to be implemented in second half of the term of this Opinion will continue these trends, restoring the functioning of safe passage for juveniles and kelts in the North Santiam and of water quality in the South Santiam. Full implementation of the habitat restoration program will ensure that habitat affected by Project operations can serve its conservation role for the species.

After reviewing the effects of the RPA combined with the Proposed Action, the status of the species, the environmental baseline, and cumulative effects, NMFS has determined that the functioning of critical habitat is likely to improve and to remain functional. NMFS therefore concludes that the Proposed Action and the RPA, combined, are not likely to result in the destruction or adverse modification of designated critical habitat for UWR Chinook salmon.

9.11.2 UWR Winter Steelhead

9.11.2.1 Effects of the RPA

The RPA specifies many significant measures that will reduce the adverse effects of the Willamette Project on the UWR steelhead DPS and will bring about proper functioning of primary constituent elements (PCEs) of its critical habitat. Many of the RPA measures specifically address key limiting factors/threats facing each population and caused by the Willamette Project: lack of passage, the degraded quality of the remaining habitat downstream of the dams, and the risk of genetic introgression from out-of-ESU hatchery fish spawning in the wild. By implementing the RPA, it is very likely the status of the populations in the North and South Santiam rivers, designated core populations (see Chapter 3), will improve significantly. . With implementation of the RPA, NMFS expects that the status of the DPS, including the four VSP parameters, will improve significantly compared to their potential status under the Proposed Action.

As shown in Table 9.11-1, several major RPA measures will be completed between 2015 and 2024 including passage at Detroit Dam, which will provide access to and from historical habitat that is currently blocked and temperature control to improve downstream habitat in a different location. Most of these measures are major construction projects that take a significant amount of time to plan, fund, and execute. For a full description of the authorization and funding processes needed for these types of measures, see the Supplemental Biological Assessment (USACE 2007I). It is not economically and technically feasible to move the timelines for many of these measures forward significantly due to their magnitude and the time needed for studies, design, authorization and construction.

Given these constraints, the anticipated population status improvements will begin in the next 15 years and continue to increase over the 15-year term of this Opinion. It will take several generations of the steelhead life cycle to respond to the positive improvements in the operation of the Willamette Project and associated measures. Therefore, significant improvements in the status of the DPS will continue to accrue in the next 30 years (approximately six generations). While implementation of these RPA measures will occur during the term of this Opinion, their full effects on population metrics (e.g., abundance, productivity) will occur over a considerable period of time after implementation. Therefore, NMFS expects that substantial improvements to the ESU will result from the implementation of the Proposed Action and the RPA.

In addition to the major measures specified in Table 9.11-1, there are numerous other near-term measures such as changes to flow, screening irrigation diversions, hatchery program modifications, and habitat mitigation projects that are included in the RPA. The near-term measures in Table 9.11-1 directly address project effects on listed fish and critical habitat without requiring as many years to implement as the measures discussed above. A third group of measures, such as conducting RM&E studies, developing fish operations manuals, project planning, and implementing the WATER collaborative process, will begin in the near term. Although this third group of activities also has not been included in the summary table, these are essential tasks that will facilitate construction of the large structures as well as guide annual operations, all of which will benefit UWR steelhead.

Difference between the Proposed Action and RPA

The effect of the RPA measures on UWR steelhead is significantly different than the effect of the Proposed Action. The Proposed Action mainly provided for further studies to consider options such as passage facilities to historical upstream habitat, as well as a major downstream habitat improvement measure of temperature control. In addition, the RPA includes measures to improve degraded downstream habitat through changes to flows, screens at irrigation diversions, hatchery improvements, and other habitat improvement projects. These RPA measures are significant because UWR steelhead are currently limited to degraded downstream habitat in one of the important subbasins (North Santiam). The RPA measures both provide access to higher quality habitat and improve downstream habitat conditions, which together will provide significant enough improvements to allow the UWR steelhead DPS to increase in numbers, productivity, spatial structure, and diversity.

9.11.2.2 UWR Steelhead Populations—Summary of Effects of the RPA

The following is a population-by-population summary of the benefits of the RPA on UWR steelhead populations. It is important that this section be read in the context of Chapter 7, "Summary of Effects of the Proposed Action on UWR Chinook and Steelhead."

Calapooia Steelhead

Impaired physical habitat from past and/or present land uses is a key limiting factor for the Calapooia population, which is at a moderate risk of extinction.

- Address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem and Willamette tributaries

\- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use* *project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

Because the RPA does not require that habitat projects be located within the Calapooia subbasin, NMFS does not assume that this RPA measure will improve the status of this steelhead population or the functioning of PCEs in the Calapooia subbasin.

South Santiam Steelhead

Competition with hatchery-origin summer steelhead smolts, inadequate passage facilities at Foster and Green Peter dams, and degraded habitat downstream of Foster Dam are key limiting factors for this population, which is at moderate risk of extinction.

- The RPA will reduce impacts associated with the summer steelhead hatchery program.
  - *RPA 6.1.6: reduces the risk of residualism by allowing the volitional emigration of hatchery summer steelhead from the point of release over an extended period of time and removing non-migrants from the system.*
  - *RPA 6.1.7: ends the recycling of hatchery-origin summer steelhead for harvest purposes by September 1st of each year to decrease the risk of straying and spawning in the wild.*
  - *RPA 6.1.8: adjusts the releases of summer steelhead in the Santiam basin. More summer steelhead are caught by recreational fishers in the South Santiam, but a disproportionate number of smolts are released in the North Santiam. Aligning releases with fishery needs will reduce the risk of competition with listed winter steelhead for spawning sites.*
  - *RPA 6.1.9: ensures that the Action Agencies will cooperate with ODFW to reduce the risks to winter steelhead of straying and spawning of summer steelhead based on information acquired through research and monitoring.*
- The RPA requires rebuilding of the adult collection facility at the base of Foster Dam to allow better capture and handling of winter steelhead for outplanting into historically accessible habitat above the dam.
  - *RPA 4.6: complete construction of adult fish collection and handling facilities at Foster by December 2013 and begin operations by March 2014.*
- Construction and operation of one or more new adult release sites above Foster Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult steelhead outplanted above the dam.
  - *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*
- The RPA addresses the long-term need to improve reservoir and dam passage survival at Foster Dam for juvenile steelhead and kelts.
  - *RPA 4.13: The Action Agencies will evaluate a range of potentially beneficial actions for listed fish species at Project dams and reservoirs, including Foster, in their development of the Willamette Configuration and Operation Plan (COP). This will include facilities and operations that require detailed study including feasibility studies and environmental permitting such as long-term fish passage solutions at Foster Dam.*

- The RPA requires continuation of the spill program for juvenile steelhead passage at Foster Dam, which provides better passage survival that turbine passage

- *RPA 2.8: continuation of spill for juvenile steelhead passage at Foster from April 15 to May 15 each year*

- Interim operational measures at Green Peter and Foster dams will help to restore more normative seasonal water temperatures

- *RPA 5.1: identify interim measures by March 2010*

- *RPA 5.1.3: evaluate more complex measures (requiring detailed environmental review, permits, and/or congressional authorization) by April 2011.*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat.

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*

- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*

- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

- Unscreened diversions create impediments or barriers to juvenile steelhead migrants.

- *RPAs 3.2 and 3.3.: Reclamation will require that existing, new, and renewed contracts for stored water include conditions that protect fish from entrainment into diversions.*

These measures (especially the hatchery program improvements and increases in downstream passage survival at Foster Dam) are expected to significantly improve the status of the South Santiam steelhead population. Natural-origin winter steelhead are already collected at Foster and released upstream, but the RPA will ensure that these operations and juvenile and kelt movements downstream entail less injury, mortality, and stress. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin steelhead as these measures become operational. These actions will also improve the functioning of PCEs in designated critical habitat including:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).

- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.2; 5.1.3; and 7.1.3).

- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.7; 2.8; 3.2; 3.3; 4.6; 4.7; 4.13; and 7.1.3).

North Santiam Steelhead

Competition with hatchery-origin summer steelhead smolts, loss of access to historical habitat above Detroit Dam, and altered habitat downstream of Big Cliff Dam are key limiting factors for this population, which is at moderate risk of extinction.

- The RPA will reduce impacts associated with the summer steelhead hatchery program.

- *RPA 6.1.6: reduces the risk of residualism by allowing the volitional emigration of hatchery fish from the point of release over an extended period of time and removing non-migrants from the system.*
- *RPA 6.1.7: ends the recycling of hatchery-origin summer steelhead for harvest purposed after September 1st of each year to decrease the risk of straying and spawning in the wild.*

- The RPA will significantly reduce the problem with altered water temperatures released from Detroit/Big Cliff dams in natural production areas downstream by requiring the Action Agencies to construct a Water Temperature Control Facility, or alternative operational measures, at Detroit Dam.

- *RPA 5.1.1: identify and evaluate interim operational measures at Detroit and if feasible, begin implementation in Water Year 2009.*
- *RPA 5.2: make structural modifications or major operational changes at Detroit Dam for improved water quality, initiating planning by 2010, completing construction by December 2018, and beginning operations by March 2019.*

- The RPA addresses the potential need to provide upstream adult passage at Detroit and Big Cliff dams. Replacing Minto Trap will allow for capture and handling of steelhead for outplanting, if determined necessary, with reduced levels of stress, injury, and mortality.

- *RPA 4.2: If determined necessary by NMFS, in coordination with the FPHM (WATER subcommittee), the Action Agencies will collect adult steelhead at the Minto trap and release them above Detroit and/or Big Cliff dams.*

- Construction and operation of new adult release sites above Detroit Dam will increase upstream passage survival and reduce pre-spawn mortality by minimizing stress and injury of adult Chinook salmon outplanted above the dams.

- *RPA 4.7: complete site/concept study by February 2009, establish priorities, and complete construction of all selected sites by June 2012*

- The RPA addresses the potential need to provide downstream juvenile steelhead and kelt passage at Detroit and Big Cliff dams if NMFS determines that steelhead should be outplanted above Detroit Dam.

- *RPA 4.12.3: initiate planning by 2015, make "go/no go" decision by end of 2017; complete construction by end of 2023, begin operations by March 2024.*

- The RPA will address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows, altered seasonal flow patterns, and the maintenance of revetments) on downstream habitat

- *RPA 2.4.4: enabled by implementation of RPA measures 2.4.1-2.4.3, modify operations to optimize system's ability to meet improved flow objectives to the degree feasible, by January 2012.*
- *RPA 2.7: test pilot "environmental" or "pulse" flows below Project dams to achieve channel-forming and channel-maintenance flows; implement where feasible without compromising authorized Project purposes.*
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

These measures, especially the hatchery program improvements, providing safe upstream/downstream passage at Big Cliff/Detroit dams, and improvements in water temperatures below Big Cliff Dam, are expected the significantly improve the status of the North Santiam population. Natural-origin steelhead will have the opportunity for successful spawning, incubation, and rearing in the reach above Detroit and juveniles will emigrate downstream with reduced rates of injury and mortality. NMFS expects increases in the abundance, productivity, spatial structure, and diversity of natural-origin winter steelhead as these measures become operational. These actions will also improve the functioning of PCEs in critical habitat:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development (specifically RPA measures 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (RPA 2.4.4; 2.7; 5.1.1; 5.2; and 7.1.3).
- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 3.2; 3.3; 4.2; 4.6; 4.7; 4.12.3; and 7.1.3).

Molalla Steelhead

Insufficient streamflows due to land use-related water withdrawals resulting in impaired water quality and reduced habitat availability and impaired physical habitat from past and/or present land use practices are secondary limiting factors for this population, which is at a moderate risk of extinction.

- The RPA will address effects of the Willamette Project (specifically, maintenance of revetments) on habitat in the mainstem Willamette and tributaries.
- *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*

Because the RPA does not require that habitat projects be located in the Molalla subbasin, NMFS does not assume that this RPA measure will improve the status of this steelhead population or the functioning of PCEs in the Molalla subbasin.

All UWR Steelhead Populations

The following RPA actions, located. or affecting conditions within the mainstem Willamette, will affect all populations of UWR steelhead.

- RPA 2.3: obtain NMFS' approval before changing mainstem Willamette (Albany and Salem) flow objectives, to ensure that flow-related habitat needs of UWR steelhead for rearing and juvenile and adult migration are fully considered.
- Address effects of the Willamette Project (specifically, reduced frequency of channel-forming flows and the maintenance of revetments) on downstream habitat
  - *RPA 7.1.3: implement at least two habitat restoration projects by 2010; fund and complete additional projects each year from 2011 through 2023, the term of this Opinion.*[57] *Use project selection criteria developed through RPA 7.1.2 to identify priority projects for funding.*
- Ensure that the availability of adequate water for fish and habitat protection in the tributaries and in the mainstem Willamette is not precluded by the water contract program.
  - *RPA 3: Reevaluate the availability of water from conservation storage for the water contract program and reinitiate consultation if future irrigation demands exceed 95,000 acre-feet.*

These actions will improve the functioning of PCEs in designated critical habitat:

- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development (specifically RPA measures 2.3; 7.1.1; and 7.1.3).
- Freshwater rearing corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival (RPA 2.3; 7.1.1, and 7.1.3).

9.11.2.3 Conclusions—UWR Steelhead

9.11.2.3.1 Jeopardy Analysis

The risk of extinction for the four UWR steelhead populations is moderate and the improvements in conditions that will result from the RPA and Proposed Action, combined with recent improvements in project facilities and operations (Chapter 4), will address limiting factors caused by the Project. The RPA is designed to increase the abundance and productivity of the South and North Santiam populations, to increase the spatial structure (geographic range) of the North Santiam population, and to improve the diversity (locally adapted genotypes) of all four populations (including the Calapooia and Molalla). The relationship between the RPA improvements, population viability, and the risk of extinction is similar to that described in Section 9.11.1.3 for UWR Chinook salmon, with a few differences. The Action Agencies are already passing winter steelhead upstream of Foster Dam, but the RPA requires that the adult collection facility be rebuilt to allow safer capture, handling, and transport to will increase the survival and therefore productivity of the outplanted fish. The downstream passage facilities, used by both juvenile steelheads and kelts, also will be improved to increase survival. Interim and long-term water temperature control operations in the North Santiam River and ongoing reservoir management to meet flow objectives will improve conditions that have depressed natural production below the dams and contributed to the populations' moderate risk of extinction. Hatchery reforms will reduce competitions for spawning sites with out-of-basin summer steelhead and the risk of genetic introgression, promoting life history diversity and increasing the abundance and productivity of each population.

Measures implemented in the first half of the term of this Opinion will further reduce the species' risk of extinction. These include operations to meet mainstem and tributary flow objectives, which were initiated in 2000 and are beginning to positively influence adult returns. These will continue under the RPA and Proposed Action. The Action Agencies will conduct flow studies to ensure that the flow objectives are adequate, based on gauging stations they will establish or improve. By January 2011, the Action Agencies will have determined whether the Opinion's flow levels should be revised to better meet the species needs and will meet any revised flow objectives to the extent possible given all project purposes. Thus, the Action Agencies will improve their operations, reducing negative effects on the listed species and their critical habitat, and will adapt their operations to new information on physical habitat properties, including those related to climate change (Section 5.1.7).

Reclamation will immediately improve its water contracting program. All (existing, new, and renewed) contracts will be subject to the availability of water, and when there is not enough water to meet minimum flow targets and irrigation contracts, instream flows will be preserved. All contracts will require that irrigation intakes and diversion dams be screened to preclude entrainment (fish sucked into irrigation diversions) and the headgate requirement will ensure that water diversions can be stopped when not needed, or when directed by OWRD. These reforms will minimize fish entrainment and, particularly during "deficit" water conditions, preserve instream flows for fish habitat needs. In addition, all existing water diversions served by water contracts will be screened to prevent entrainment by April 1, 2010.

In the short-term, the Action Agencies will continue to pass adult UWR steelhead above Foster on the South Santiam to enhance spatial structure. Fish survival and productivity will be improved by the outplanting program, managed according to an annual Fish Operations Plan that are coordinated with the Services and ODFW and which will address how, where, and when outplanted fish will be collected, held, marked, sampled, transported, and released, and will incorporate changes needed to further protect these fish based on research and monitoring.

By spring of 2009, interim temperature control operations at Detroit will improve water temperatures in the North Santiam, increasing the survival of eggs, juveniles, and prespawning adults and thus population productivity. The Action Agencies will design and begin to use new adult release sites above the dams by 2012. These new sites, like the improved adult collection facilities, will reduce stress and injury and thus the risk of prespawning mortality.

The Action Agencies will also begin to upgrade existing adult fish collection and handling facilities in the first half of the term of the Opinion. Dates for beginning operations at the new facilities are March 2013 in the North Santiam and 2014 at Foster Dam (South Santiam. Once construction is complete, adult fish will experience reduced levels of stress and injury, which is expected to lessen pre-spawning mortality.

In addition to these measures, which will immediately (during the first one-to-seven years of this Opinion) improve population viability and reduce the risk of extinction, the RPA requires that the Action Agencies complete various RM&E efforts, feasibility studies, and where needed, NEPA analysis. NMFS expects that these evaluations will lead to the construction of facilities and adjustments in operations during the second half of the term of this Opinion that will ensure that conditions are optimized for all affected life stages of UWR steelhead. These will include:

- Adjustments to mainstem and tributary flow objectives and ramping rates to meet the needs of the species over all affected life stages
- Operations for water quality (temperature and dissolved gas) and construction of new facilities
- Construction of improved juvenile and kelt passage facilities
- Full implementation of the habitat restoration program
- Adaptation of flow management and water quality measures to changing climatic conditions

The near- and longer-term actions described above will address the effects of the Willamette Project on all life stages of UWR steelhead that occur within the Willamette Basin: adult migration, spawning and incubation, juvenile rearing, and juvenile and kelt downstream migrations.

Other measures taken by the Action Agencies under the environmental baseline (as required by the 2008 FCRPS RPA; NMFS 2008a) will improve the survival and condition of juvenile UWR Chinook in the lower Columbia River and estuary. The effects of the Willamette Project on habitat are very small in the lower Columbia and estuary, with slight to negligible adverse effects on viability (Section 5.11). However, the FCRPS RPA includes beneficial measures to reduce smolt predation by Caspian terns and Northern pikeminnows, and a significant estuary habitat restoration program to ensure that biological requirements are met. These actions will benefit yearling steelhead from the Willamette Basin during the critical period prior to ocean entry.

After reviewing the effects of the RPA measures combined with the Proposed Action, which address significant adverse impacts of the Willamette Project (lack of effective passage, degraded water quality and physical habitat properties, and adverse effects of hatchery practices on population viability), the rangewide status of the species, the effects of the environmental baseline (degraded spawning and rearing habitat in tributaries below Project dams), and cumulative effects (reasonably certain non-federal activities that are intended to benefit these status of the species mixed with those likely to have adverse effects), NMFS has determined that the UWR steelhead DPS is expected to survive with an adequate potential for recovery. The actions implemented in the first few years will protect the species against the short-term risk of extinction while longer-term measures are designed and constructed. NMFS therefore concludes that the RPA and Proposed Action, combined, are not likely to jeopardize the continued existence of the UWR steelhead DPS.

9.11.2.3.2 Critical Habitat Analysis

The measures described in the RPA combined with the Proposed Action will also improve the functioning of PCEs, restoring the ability of primary constituent elements of habitat needed for the conservation of the species. The actions described above will significantly improve the following PCEs over the term of the Opinion:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development
- Freshwater rearing sites with water quantity and floodplain connectivity supporting juvenile development

- Freshwater migration corridors free of obstruction with water quality and quantity supporting juvenile and adult mobility and survival

In the first one to seven years, the Action Agencies will rebuild the adult steelhead collection facilities and will build new release sites above Project dams. These measures will improve safe passage to high quality freshwater spawning sites that have water quantity and quality and substrate that support spawning, incubation, and larval development. Ongoing operations to meet flow objectives in the South and North Santiam rivers, and operations that preserve instream flows during deficit water conditions will ensure adequate water quantity in spawning, rearing, and early migration areas below the dams. The Action Agencies will implement interim temperature control operations at Detroit Dam in the North Santiam to provide water quality needed for adult migration and holding, spawning and incubation, and juvenile survival. All existing water diversions will be screened by April 1, 2010, also contributing to safe passage in the juvenile migration corridor.

The actions to be implemented in second half of the term of this Opinion will continue these trends, restoring the functioning of safe passage for juveniles in three of the four tributaries with Project dams and of water quality in the Middle Fork and South Santiam. Full implementation of the habitat restoration program will ensure that habitat affected by Project operations can serve its conservation role for the species.

After reviewing the effects of the RPA combined with the Proposed Action, the status of the species, environmental baseline, and cumulative effects, NMFS has determined that the functioning of designated critical habitat is likely to improve and remain functional. NMFS therefore concludes that the Proposed Action and the RPA, combined, are not likely to result in the destruction or adverse modification of designated critical habitat for UWR steelhead.

9.11.3 Snake River, Upper Columbia River, Middle Columbia River, and Lower Columbia River Salmon and Steelhead

As described in Sections 8.3-8.7, NMFS has concluded that, taking into account the current status of 11 species of Interior and Lower Columbia Basin salmon and steelhead and of critical habitat designated for 10 of those species,[58] the condition of the environmental baseline and cumulative effects within the action area, the Proposed Action is not likely to jeopardize the continued existence of any of these species or to destroy or adversely modify critical habitat. Adverse effects of the Proposed Action were limited to a very small decrease in average monthly flows in the lower Columbia River and estuary during February through June and very small reductions in the delivery of turbidity and large wood, trapped behind Project dams. These were expected to result in “slight to negligible” effects on habitat conditions, including the PCEs safe passage in the juvenile migration corridor and water quantity, turbidity, floodplain connectivity, large wood, and natural cover in freshwater/estuarine rearing areas, and on population viability. In addition, NMFS anticipates that habitat conditions in the lower Columbia River and estuary will improve over the term of this Opinion due to relocation of Caspian terns to sites outside Columbia Basin, ongoing control of Northern Pikeminnow predation, and implementation of a 10-year estuary habitat program under the 2008 FCRPS RPA (NMFS 2008a). These future improvements in baseline habitat conditions are expected to exceed the small to negligible

[58] NMFS has not yet designated critical habitat for LCR coho salmon.

adverse effects of the RPA and Proposed Action. Thus, NMFS concludes that the Proposed Action and the RPA are not likely to jeopardize the continued existence of any of these species or to destroy or adversely modify critical habitat.

9.11.4 Southern Resident Killer Whales and Southern DPS of North American Green Sturgeon

After conducting the analyses included as Appendices A and B to this Opinion, NMFS determines that the Proposed Action and the RPA are not likely to adversely affect either species or critical habitat designated for the Southern Resident killer whale.

Chapter 10 Reinitiation of Consultation

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10 REINITIATION OF CONSULTATION

As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the Action Agencies must consult with NMFS to determine whether specific actions will be taken to address such events including but not limited to ceasing or modifying the causal activity.

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Chapter 11
Incidental Take Statement

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11 INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits any taking (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to Section 4(d) of the ESA extend the prohibition to threatened species. Harm is defined to include significant habitat modification or degradation that results in death of or injury to listed species by significantly impairing behavioral patterns such as spawning, rearing, feeding, and migrating (50 CFR §222.102; NMFS 1999f). The ESA does not define harassment nor has NMFS defined this term through regulation. However, for this Opinion, NMFS considers an action to be harassment if it is an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity by a Federal agency or applicant (50 CFR §402.02). Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of the incidental take statement.

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize these impacts, and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. The measures described in this section are nondiscretionary.

If USACE, Reclamation, or BPA fails to comply with the terms and conditions of this incidental take statement, they may no longer be in compliance with the ESA. To monitor the impact of incidental take, USACE, Reclamation, and BPA must report the progress of the action and its effect on each listed species to NMFS, as specified in this incidental take statement (50 CFR §402.14(i)(3)).

11.1 Amount or Extent of Anticipated Take

Incidental take will occur as a result of the continued operation of the Willamette Project dams and reservoirs, maintenance of revetments, administration of Reclamation's water contract program, implementation of on- and off-site habitat mitigation measures, operation of the Willamette Hatchery Mitigation Program, and RM&E activities. Because of the inherent biological characteristics of aquatic species such as listed salmon and steelhead, the dimensions and variability of the river system, and the operational complexities of hatchery actions, it is not possible to determine precise (or even to quantify) levels of mortality for juveniles and adults attributable to many features of the RPA and Proposed Action (e.g., reduced availability of habitat for spawning or rearing if tributary flow objectives are not met; predation by program hatchery-origin fish on listed fish below release locations). The following sections therefore specify an *amount* of take where possible (collection of adults for outplanting or broodstock; juvenile or kelt project passage, Sections 11.1.1 and 11.1.5), but otherwise specify a geographic and temporal *extent* of take (Sections 11.1.2 through 11.1.5).

These are the maximum amounts or extents of take that NMFS anticipates will occur as a result of the RPA and Proposed Action. If actual take exceeds an amount or (geographic and temporal) extent specified here, it is likely that the authorized incidental take allowed under this Opinion has been exceeded by some indeterminate amount. NMFS will evaluate the best science available and determine whether authorized take has, in fact, been exceeded and if reinitiation of consultation is required.

As the RPA and Proposed Action are implemented, incidental take in the forms of adult and juvenile passage mortality and due to adverse water quality and quantity conditions is expected to decline. With respect to fish passage, RPA measure #9.3 includes RM&E measures that will lead to the development of performance objectives for the Project. These standards will be consistent with NMFS (2008e) or as determined through the Fish Passage and Management Committee of WATER and agreed to by NMFS. As these standards are developed, they will replace the permitted amount of take due to fish passage as described in this statement. Similarly, RM&E on mainstem Willamette and tributary flows are expected to lead to amendments to flow objectives (RPA measures #2.3; 2.4.2-2.4.4; 2.6.4; 2.10; and 9.2).

11.1.1 Amount or Extent of Take from Operation of Willamette Project Dams & Reservoirs

NMFS anticipates that the continued operation of the Willamette Project dams and reservoirs under the PA and RPA will result in incidental take of the species considered in this opinion (see Environmental Baseline [specifically Sections 4.2, 4.3, 4.5, 4.6, and 4.11]; Effects of the Proposed Action [Sections 5.2, 5.3, 5.5, 5.6, and 5.11]; and Effects of the RPA [Section 9.10]). For UWR Chinook salmon and UWR steelhead, which spawn and/or rear in several of the subbasins with Project dams, effects will include juvenile and adult passage mortality as well as effects on habitat conditions below the dams (i.e., in the tributaries and mainstem Willamette and in the lower Columbia River). Take of individuals of the other 11 species (LCR steelhead, LCR Chinook Salmon, LCR coho Salmon, CR chum salmon, MCR steelhead, SR steelhead, SR fall Chinook salmon, SR spring/summer Chinook salmon, SR sockeye salmon, UCR steelhead, and UCR spring Chinook salmon) would be limited to those that occurred due to adverse effects on habitat conditions in the lower Columbia River and estuary (e.g., altered flows, interrupted transport of large wood and turbidity), but these were determined to be slight to negligible (i.e., did not rise to the level of take; Section 5.11).

NMFS expects, at most, the (quantifiable) amounts of incidental take of UWR Chinook and steelhead due to project passage, including trapping, transporting, and outplanting adults as well as juvenile passage, in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins shown in Table 11.1-1. The maximum (quantifiable) amounts of incidental take of UWR steelhead adults (including kelts) and juveniles are shown in Table 11.1-2.

The relationships between tributary flows and water quality, the functioning of rearing habitat, and carrying capacity (one of the environmental factors controlling abundance and productivity) are explained in Appendix C and in Sections 5.2-5.10 (see subsections titled “Water Quantity and Hydrograph,” “Water Quality,” and “Physical Habitat Quality”). The major sources of take due to these features of the RPA and Proposed Action are the reduced availability and functioning of spawning, rearing, and juvenile and adult migration habitat. The expected geographic or temporal extent of take are shown for each species in each part of the action area in Tables 11.1-3a through 11.1-6c.

11.1.2 Extent of Take from Maintenance of Revetments

The relationships between maintenance of revetments, the functioning of rearing habitat, and carrying capacity are explained in Sections 5.2-5.10 (see subsections titled "Physical Habitat Quality"). The major source of take due to maintaining revetments under the Proposed Action and RPA is the reduced availability of rearing habitat. The expected geographic or temporal extent of take are shown for each species in each part of the action area in Tables 11.1-3a through 11.1-7.

11.1.3 Extent of Take from Administration of Reclamation's Water Contract Program

The relationships between actions that will occur as a result of administering water contracts, habitat condition, and carrying capacity (a factor in population abundance and productivity) are explained in Chapter 9 (see RPA measure #3). The major sources of take and the expected geographic or temporal extent of take due to effects of water contracting under the Proposed Action and RPA are: 1) reduced availability of rearing habitat between points of diversion and the confluence of each tributary with the Willamette during July and August and 2) mortality due to entrainment at points of diversion during July and August (but only through 2009, after which all existing diversions will be screened) (Tables 11.1-3a through 11.1-6c).

11.1.4 Extent of Take from Implementation of Habitat Measures

Habitat restoration projects could be implemented in the mainstem Willamette and in any of the tributary subbasins with Project dams or revetments. Some habitat restoration projects will have negative effects during construction (e.g., sediment plumes, localized and brief chemical contamination from machinery, or the destruction or disturbance of some existing riparian vegetation). These are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). However, due to these short-term adverse effects, incidental take is reasonably certain to occur.

Take of listed salmonids resulting from habitat projects developed to implement this RPA and authorized, funded, or carried out by the USACE that are consistent in type, design, and implementation to those covered by the Endangered Species Action Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act, Essential Fish Habitat Consultation for the Revised Standard Local Operating Procedures for Endangered Species (SLOPES IV) to Administer Certain Activities Authorized or Carried Out by the Department of the Army in the State of Oregon and on the North Shore of the Columbia River, falls within the take provisions of that Biological Opinion (NMFS 2008f). Take resulting from projects that fall outside the explicit criteria in the SLOPES IV Biological Opinion will require separate and subsequent consultation.

Similarly, take of listed salmonids resulting from habitat projects developed to implement this RPA and authorized, funded, or carried out by BPA that are consistent in type, design, and implementation to those covered by the Endangered Species Action Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Implementation of the Bonneville Power Administration Habitat Improvement Program in Oregon, Washington, and Idaho, CY 2007-CY2011 (HIP II), falls within the take provisions of that Biological Opinion (NMFS 2008d). Take resulting from projects that fall outside the explicit criteria in the HIP II Biological Opinion will require separate and subsequent consultation.

NMFS authorizes no additional take of ESA-listed species (beyond that previously authorized by the SLOPES IV and HIP II Biological Opinions) for the habitat restoration activities required by the RPA and Proposed Action in this Opinion. NMFS will work with the Action Agencies to develop additional programmatic biological opinions to address off-site mitigation projects and their associated take.

11.1.5 Amount or Extent of Take from Operation of the Willamette Hatchery Mitigation Program

The PA and RPA require programs and processes to ensure that the Willamette Project hatchery mitigation programs do not reduce the viability of the listed species. Incidental take from these hatchery programs is assessed in the effects chapters and is further described in the Supplemental Biological Assessment and relevant HGMPs. For the summer steelhead and rainbow trout hatchery programs that involve solely incidental take of listed species, ESA take for those programs is authorized in this ITS for these hatchery programs. For the Chinook hatchery programs, incidental and direct take of listed natural (unclipped) Chinook and steelhead is proposed. The incidental take of listed steelhead from the Chinook hatchery programs are authorized in this ITS. However, authorization of the incidental and direct take of listed Chinook from the Chinook hatcheries will be processed under limit #5 (the artificial propagation limit) of the 4d Rule (June 28, 2005; 70 FRN 37160).

Levels of incidental mortality for juveniles and adults attributable to hatchery operations per the RPA and Proposed Actions are, in most cases, not quantifiable at the present time (e.g., predation by program hatchery-origin fish on listed fish below release locations; competition and density dependent effects in the Lower Willamette and estuary). Though the levels of mortality to juvenile and adults cannot be measured directly for specific artificial propagation programs, impacts of some of the general effects of artificial propagation can be inferred through other measurements and monitoring and evaluation activities. The general and specific effects of the hatchery programs on listed fish are fully described in Chapter 5. It is possible to estimate take of the listed species for certain hatchery activities (e.g., numbers of fish handled and collected during broodstock collection, see Tables 11.1-1 and 11.1-2). For the other activities where take is currently unquantifiable, NMFS estimates the geographic and temporal extent of each type of take in Tables 11.1-3a through 11.1-7.

11.1.6 Amount or Extent of Take from RM&E activities

This section identifies the authorized incidental take allowed under this Opinion for RM&E actions (see Effects of the Proposed Action [Section 5.1] and Effects of the RPA [Section 9.10]). Under the PA and RPA, the Willamette Project Action Agencies, or their contractors, are required to implement the following RM&E actions:

1. Monitor compliance with the effectiveness of flow and ramping measures (RPA measure #9.2);
2. Support performance monitoring and adaptive management related to fish passage measures (RPA measure #9.3);
3. Support performance monitoring and adaptive management related to water quality actions (RM&E measure #9.4);
4. Support performance monitoring and adaptive management related to hatchery actions (RM&E measure #9.5); and
5. Support performance monitoring and adaptive management related to habitat restoration (RM&E measure #9.6);

Many of these research, monitoring, and evaluation actions will result in short-term adverse impacts on the listed species. The primary adverse effects will be in the form of incidental “take,” a major portion of which takes the form of harassment. Harassment generally leads to stress and other sub-lethal effects and is caused by observing, capturing, and handling fish.

11.1.6.1 Amount or Extent of Incidental Take from Flow and Ramping RM&E Actions

Incidental take due to habitat alterations caused by flow and ramping rate RM&E actions would not exceed that described for “Tributary flows” in Tables 11.1-3a through 11.1-6c. In addition, juvenile Chinook and steelhead may be handled or tagged. NMFS has determined that mortalities, based on consideration of similar studies to date, are likely to be less than 3%. Therefore, mortality of up to 3% of juvenile Chinook and steelhead handled is permitted as incidental take.

11.1.6.2 Amount or Extent of Incidental Take from Fish Passage RM&E Actions

Incidental take from fish passage RM&E will include harassment, handling, injury, and mortality of adults at trapping sites; handling and mortality of adults during transport; juvenile injury and mortality during project passage; and juvenile trap mortality at the lower end of the study site. The amount or extent of take expected from each these activities is shown in Tables 11.1-3a through 11.1-6c.

11.1.6.3 Amount or Extent of Incidental Take from Water Quality RM&E Actions

Incidental take from water quality RM&E actions will include harassment of adults and juveniles during construction of monitoring stations and/or during measurement of physical and biological metrics, although the harassment of listed salmon or steelhead during spawning while constructing or using monitoring stations is not permitted.

11.1.6.4 Amount or Extent of Incidental Take from Hatchery RM&E Actions

Incidental take from hatchery RM&E actions will include observation, harassment, carcass sampling, injury, and mortality during broodstock collection activities, spawning surveys, and release of juvenile Chinook above and below Project dams, as shown in Tables 11.1-3a through 11.1-6c. Incidental take of listed winter steelhead will be similar, with the addition observation, harassment, and collection of juveniles during the hatchery summer steelhead genetic study (Tables 11.1-3b and 11.1-4b).

11.1.6.5 Amount or Extent of Incidental Take from Habitat Restoration RM&E Actions

Take resulting from habitat RM&E will occur primarily as harassment or harm caused by handling, increased delivery of contaminants and fine sediments to streams, and human activities in or around streams. Take from these activities will occur more sporadically and within a larger area than take from in- and near-water construction. For these activity categories, the extent of take is best identified by the total number of projects implemented each year. The Action Agencies shall begin initiating individual consultations on research, monitoring, and evaluation projects not involving in-water or near-water construction if over 100 of these projects are implemented in a given calendar year. The first 100 of these projects are covered under this programmatic consultation.

11.1.6.6 Summary of Amount or Extent of Incidental Take from All RM&E Actions

As a result of implementing the RM&E actions required by the PA and the RPA, NMFS' best estimate of the average take that is likely to be experienced by the salmon and steelhead species considered in this Opinion is provided in Tables 11.1-1 through 11.1-7.

11.1.7 Effect of the Take

Earlier in this Opinion (Section 9.11), NMFS determined that the RPA and Proposed Action, combined, are not likely to result in jeopardy to any of the 13 ESA-listed species. Thus, the effect of the amount and extent of take associated with these actions is fully considered in Chapter 9 of the Opinion.

Table 11.1-1 Estimates of the (quantifiable) amount of incidental take of UWR Chinook salmon associated with operation of Willamette Project dams and reservoirs (based on Willis 2008 and ODFW 2004a, 2008a,b).

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
North Santiam	Minto Trap	Adults	Handled: up to 5,000 fish annually including broodstock collection of up to 800 fish each year Injury: up to 2% of fish handled Mortality: up to 4% of fish handled
	Haul from Minto and release above Detroit Reservoir or below Big Cliff Dam (outplanting of adult Chinook)	Adults	Handled: up to 4,200 fish annually Mortality: up to 1% of fish handled
	Outmigrant passage at Detroit and Big Cliff	Juveniles (primarily produced by hatchery-origin spawners)	Mortality: up to 65%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
South Santiam	Foster Trap	Adults	Handled: up to 7,000 fish annually including broodstock collections of up to 1,400 each year Injury: up to 1% of fish handled Mortality: up to 1% of fish handled
	Haul from Foster trap and release at sites located above Foster Reservoir or below Foster Dam	Adults	Handled: up to 5,600 fish annually Mortality: 1% of fish handled
	Downstream passage at Green Peter and Foster dams	Juveniles (primarily produced by hatchery-origin spawners)	Mortality: up to 83% of run past Green Peter Dam and up to 10% of run past Foster Dam
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
McKenzie	Cougar Trap	Adults	(Estimated based on the Fall Creek fish handling facility) Handled: up to 1,300 annually for years 1-7 and up to 2,600 fish annually for years 8-15 Injury: up to 1% of fish handled Mortality: up to 1% of fish handled
	Haul from Cougar trap and release at sites located above Cougar Reservoir or downstream of Cougar Dam	Adults	Handled: up to 1,300 annually for years 1-7 and up to 2,600 fish annually for years 8-15 Mortality: up to 1% of fish handled
	Downstream passage at Cougar Dam	Juveniles (primarily produced by hatchery origin spawners)	Mortality: up to 18.1% of fish passing through the turbines and up to 32% of those passing through the regulating outlet
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
Middle Fork Willamette	Fall Creek Trap	Adults	Handled: up to 2,805 fish annually for years 1-7 and up to 5,610 fish annually for years 8-15 Injury: up to 1% Mortality: up to 1%
	Haul from Fall Creek trap and release at sites above Fall Creek Reservoir	Adults	Transported: up to 2,805 fish annually for years 1-7 and up to 5,610 fish annually for years 8-15 Mortality: 1% of fish transported
	Downstream passage at and Fall Creek Dam (Downstream Migrant Facility—horns)	Juveniles	Mortality: up to 68.3 %
	Downstream passage at and Fall Creek Dam (regulating outlet)	Juveniles	Mortality: up to 41% (Downey 1992)

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
	Dexter Trap	Adults	Handled: up to 11,375 annually for years 1-7 and up to 22,750 annually for years 8-15 including broodstock collection of up to 1,600 each year Injury: up to 1% Mortality: up to 1%
	Haul from Dexter trap and released at sites above Lookout Point or Hills Creek reservoir	Adults	Transport: up to 11,375 annually for years 1-7 and up to 22,750 annually for years 8-15 Mortality: up to 2% of fish transported
	Downstream passage at Lookout Point and Dexter dams	Juveniles	Mortality: up to 21% of run
	Downstream passage at Hills Creek Dam	Juveniles (primarily produced by hatchery origin spawners)	Mortality: up to 60% of run
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

Table 11.1-2 Estimates of the (quantifiable) amount of incidental take of UWR steelhead associated with operation of Willamette Project dams and reservoirs (based on Willis 2008 and ODFW 2004a).

SUBBASIN	FEATURE	LIFE STAGE(S)	AMOUNT OF TAKE
North Santiam	Minto Trap	Adults	Handled: up to 400 fish annually for years 1-7 and up to 800 annually for years 8-15 Injury: up to 2% of fish handled Mortality: up to 1% of fish handled
	Haul from Minto and release between Big Cliff Dam and Minto barrier (or potential future release above Detroit Reservoir)	Adults	Handled: up to 1,000 fish annually for years 1-7 and up to 2,000 annually for years 8-15 Mortality: up to 1% of fish handled
	Outmigrant passage at Detroit and Big Cliff (progeny of potential future outplants above Detroit Reservoir)	Juveniles	Mortality: up to 65%
		Adults (kelts)	Mortality: up to 95%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%
South Santiam	Foster Trap	Adults	Handled: up to 600 fish annually for years 1-7 and up to 1,200 annually for years 8-15 Injury: up to 2% of fish handled Mortality: up to 1% of fish handled
	Haul from Foster trap and release at sites above Foster Reservoir or below Foster Dam	Adults	Handled: up to 5,000 fish annually Mortality: 1% of fish handled
	Downstream passage at Green Peter and Foster dams	Juveniles	Mortality: up to 83% of run past Green Peter Dam; up to 10% of run past Foster Dam
		Adults (kelts)	Mortality: up to 95%
	Fish passage RM&E (screw traps and nets)	Juveniles	Mortality: up to 1%

Table 11.1-3a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Big Cliff and Detroit dams, in the North Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Big Cliff Dam and reduced amount of adult holding habitat	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep – 17% Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-Jan – 5% Feb-Mar – 5% Apr-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature)	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	May-Aug

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Oct-Dec
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct 19% Nov 42% Dec 32% Jan 39%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 20 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism	From Minto Dam acclimation site (RM 42) to confluence with South Santiam River	Feb-May
Hatchery Chinook spawning surveys below Big Cliff Dam	Juveniles and adults	Observed; harassed; carcasses sampled	From Big Cliff Dam tailrace (RM 46.4) to confluence with South Santiam River	June-Oct
Hatchery Chinook spawning surveys above Detroit Dam	Juveniles and adults	Observed; harassed; carcasses sampled	All spawning areas in the North Santiam River and tributaries above Detroit Reservoir	June-Oct
Juvenile Chinook surveys above Detroit Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed; harassed; carcasses sampled	North Santiam River Basin above Detroit Dam	Feb-Oct

Table 11.1-3b Estimates of the type and geographic and temporal extent of incidental take of UWR steelhead associated with effects of the Willamette Project, including Big Cliff and Detroit dams, in the North Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Big Cliff Dam and reduced amount of adult holding habitat	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Mar – 5% Apr-Jun – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep – 17% Oct-Jan – 5% Feb-Mar – 5% Apr-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature) , including RM&E	Adults	Low temperatures below dams cause delayed spawning and contribute to pre-spawner straying & mortality	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	May-Jun

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Low temperatures below dams cause delayed hatching, incubation and emergence. Delayed emergence results in less over-summer growth, which likely results in reduced over-winter survival for subyearlings. Low temperatures also result in less favorable rearing habitat for yearlings and may effect use for otherwise acceptable rearing habitat within the N. Santiam.	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Jun-Sep (subyearlings) May-Sep (yearlings)
Water quality (dissolved gas)	Adults	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect pre-spawner survival. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr – 5% May – 5%

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Big Cliff Dam	Jun-Jul (incubation) Apr-Aug (rearing) Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr 5% May 5% Jun 5% Jul 5% Aug 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 20 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Minto Dam acclimation site to confluence with the South Santiam River (approx. 42 miles)	Feb-May
Hatchery summer steelhead spawning surveys below Big Cliff Dam	Juveniles and adults	Observed, harassed, carcasses sampled	From Big Cliff Dam tailrace to confluence with the South Santiam River (approx. 46.4 miles)	Dec-May
Hatchery Summer steelhead genetic study	Juveniles	Observed, harassed, and collected. Take levels determined by Research, Monitoring and Evaluation Committee of WATER.	North Santiam River Basin and tributaries below Minto Dam	Feb-Oct

Table 11.1-4a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Foster and Green Peter dams, in the South Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Foster Dam and reduced amount of adult holding habitat	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Jun – 5% Jul-Aug – 5% Sep-Oct – 25%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct-Jan – 20% Feb-Mar – 5% Apr-May – 20% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs at Foster generates more than 115% TDG below Foster Dam.	Within 1 mile downstream of the base of Foster Dam	Oct-Feb (incubation) Mar-Sep (rearing) Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct – 5% Nov – 29% Dec – 54% Jan – 65% Feb – 25% Mar – 28% Apr – 13% May – 5% Jun – 5% Jul-Sep – 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 19 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	Feb-May
Hatchery Chinook spawning surveys below Foster Dam	Juveniles and adults	Observed, harassed, carcasses sampled	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	June-Oct
Hatchery Chinook spawning surveys above Foster Dam	Juveniles and adults	Observed, harassed, carcasses sampled	All spawning areas in the South Santiam River and tributaries above Foster reservoir	June-Oct
Juvenile Chinook surveys above Foster Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	South Santiam River Basin above Foster Dam	Feb-Oct

Table 11.1-4b Estimates of the type and geographic or temporal extent of incidental take of UWR steelhead associated with effects of the Willamette Project, including Foster and Green Peter dams, in the South Santiam subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction); flow and ramp rate studies	Adults	Barrier to spawning habitat below Foster Dam and reduced amount of adult holding habitat	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Mar-May – 20%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	May-Jun (incubation) May-Apr (rearing) Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Jun – 5% Apr – 20% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause delayed spawning and contribute to pre-spawner straying & mortality	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Apr-May

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Low temperatures below dams cause delayed hatching, incubation and emergence. Delayed emergence results in less over-summer growth, which likely results in reduced over-winter survival for subyearlings. Low temperatures also result in less favorable rearing habitat for yearlings and may affect use for otherwise acceptable rearing habitat within the S. Santiam.	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	Jun-Sep (subyearlings) Apr-Sep (yearlings)
Water quality (dissolved gas), including RM&E	Adults	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect pre-spawner survival. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Foster Dam	Percent of days mean daily spill exceeds 1,400 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Apr – 5% May – 5%

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during operational WTC implementation may effect survival, especially during incubation and before emergence. Spill over approx. 1,400 cfs generates more than 115% TDG	Within 1 mile downstream of the base of Foster Dam	May-Jun (incubation) May-Apr (rearing) Percent of days mean daily spill exceeds 1,400 cfs: May – 5% Jun – 5% Jul-Oct – 5% Nov – 29% Dec – 54% Jan – 65% Feb – 25% Mar – 28% Apr – 13%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Foster Dam tailrace to confluence with the North Santiam River (approx. 37.7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
	Juveniles	Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 19 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Foster Dam to confluence with the North Santiam River (approx. 37.7 miles)	Feb-May
Hatchery summer steelhead genetic study	Juveniles	Observed, harassed, and collected. Take levels determined by Research, Monitoring and Evaluation Committee of WATER.	South Santiam River Basin and tributaries below Foster Dam	Feb-Oct

Table 11.1-5 Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Cougar Dam, in the McKenzie River subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Cougar Dam and reduced amount of adult holding habitat	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1) Jun-Oct – 5%.
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1) Nov- May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet (RO) discharge during fall drawdown and high overwinter flows effect survival, especially during incubation and before emergence. Under full powerhouse generation, spill over approx. 2,000 cfs at Cougar Dam's RO generates about 115% TDG at the USGS gage located 0.6 mile below the confluence of the RO channel and the powerhouse channel.	Within 1 mile downstream of the base of Cougar Dam	Oct-Mar (incubation) Oct-Sep (rearing) Percent of days mean daily spill exceeds 2,000 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Oct – 5% Nov – 5% Dec – 14% Jan – 20% Feb – 7% Mar – 6% Apr – 6% May – 5% Jun – 5% Jul-Sep – 5%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Cougar Dam tailrace to confluence with the McKenzie River (approx. 4.5 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Point of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 40 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook, steelhead, and rainbow trout	Juveniles	Competition, predation, and residualism.	Chinook and steelhead Smolts- McKenzie River below Leaburg Dam Rainbow Trout- McKenzie River above and below Leaburg Dam	All year
Hatchery Chinook broodstock collection at Leaburg Dam	Adults	Observed, harassed, handled, removed. Limits specified in McKenzie Chinook HGMP.	Fish ladder on Leaburg Dam	May-Oct
Hatchery fish sorting at Leaburg Dam	Adults	Observed, harassed, handled, removed	Fish ladders on Leaburg Dam	May-Oct
Hatchery Chinook spawning surveys	Juveniles and adults	Observed, harassed, carcasses sampled	McKenzie River and tributaries where spring Chinook spawn	June-Oct
Hatchery Chinook spawning surveys above Cougar Dam	Juveniles and adults	Observed, harassed, carcasses sampled	All spawning areas in the South Fork McKenzie River and tributaries above Cougar reservoir	June-Oct
Juvenile Chinook surveys above Cougar Dam to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	South Fork McKenzie River above Cougar Dam	Feb-Oct

Table 11.1-6a Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Fall Creek Dam, in the Middle Fork Willamette subbasin. (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Fall Creek Dam and reduced amount of adult holding habitat	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by regulating outlet discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx. 1,500 cfs generates more than 110% TDG below Fall Creek Dam (NMFS 1972).	Within 1 mile downstream of the base of Fall Creek Dam	Percent of days mean daily spill from Fall Creek Dam exceeds 1,500 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1):: Jan – 68% Feb – 22% Mar – 20% April – 20% May – 23% June–Oct – 5% Nov – 42% Dec – 36%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Fall Creek Dam tailrace to confluence with the Middle Fork Willamette River (approx. 7 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Hatchery RM&E *(see Table 11.1-4b)*				

Table 11.1-6b Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Dexter and Lookout Point Dams, in the Middle Fork Willamette subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Dexter Dam and reduced amount of adult holding habitat	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May-Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Nov-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Dexter Dam tailrace to below the confluence of the mainstem Willamette and McKenzie rivers (approx. 17 miles)	May-Aug

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Dexter Dam tailrace to below the confluence of the mainstem Willamette and McKenzie rivers (approx. 17 miles)	Oct-Dec
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx.1,000 cfs through 1 spillway bay at Dexter Dam generates more than 115% TDG below Dexter Dam.	Within 1 mile downstream of the base of Dexter Dam	Percent of days mean daily spill from all 7 spill bays at Dexter Dam exceeds 7,000 cfs, unless coordinated through the WATER flow management committee process (RPA 2.1): Jan – 30% Feb – 30%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Dexter Dam tailrace to confluence with the Coast Fork Willamette River (approx. 17 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Maintenance of revetments	Juveniles	Reduced amount of rearing	RM 8 (upstream end of reach with USACE revetments) to confluence with the Willamette	All year
Release of hatchery Chinook and steelhead smolts	Juveniles	Competition, predation, and residualism.	From Dexter Dam to confluence with the Coast Fork Willamette River	Feb-May
Hatchery Chinook spawning surveys above and below Fall Creek, Dexter/Lookout Point, and Hills Creek dams	Juveniles and adults	Observed, harassed, carcasses sampled	Throughout the Middle Fork Willamette subbasin in the areas where Chinook spawn	June-Oct
Juvenile Chinook surveys above Fall Creek, Dexter/Lookout Point, and Hills Creek dams to evaluate hatchery fish spawning success	Juveniles and adults	Observed, harassed, collected, sampled	Middle Fork Willamette Subbasin	Feb-Oct

Table 11.1-6c Estimates of the type and geographic or temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project, including Hills Creek Dam, in the Middle Fork Willamette subbasin (based on Willis 2008).

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Tributary flows (unable to meet minima due to hydrologic conditions; change in peak/base flows for flood damage reduction; flow and ramp rate studies)	Adults	Barrier to spawning habitat below Hills Creek Dam and reduced amount of adult holding habitat	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): May–Oct – 5%
	Juveniles	Desiccation of eggs when dewatered, barrier to marginal (shallow) juvenile rearing habitat, stranding and entrapment during flow fluctuations	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Percent of days mean daily discharge does not meet minimums in Table 9.2-2, unless coordinated through the WATER flow management committee process (RPA 2.1): Sep-May – 5% Ramping rates not to exceed 1 inch per hour during nighttime and 2 inches per hour during the day except during active flood control damage reduction operations or where physical configuration of a project does not allow this level of precision (RPA 2.6.1).
Water quality (temperature), including RM&E	Adults	Low temperatures below dams cause pre-spawner straying & mortality	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	May-Aug
	Juveniles	Elevated temperatures cause reduced egg viability and increase susceptibility to disease	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	Oct-Dec

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT OF TAKE	TEMPORAL EXTENT OF TAKE
Water quality (dissolved gas), including RM&E	Juveniles	Elevated levels of total dissolved gas caused by spilling or by regulating outlet discharge during fall drawdown and high overwinter flows affect survival, especially during incubation and before emergence. Spill over approx. 1,500 cfs generates more than 110% TDG below Hills Creek Dam.	Within 1 mile downstream of the base of Hills Creek Dam	Percent of days with mean daily spill from the regulating outlet at Hills Creek Dam exceeds 1,500 cfs: Jan – 17% Feb – 5% Mar–Oct – 5% Nov – 5% Dec – 17%
Substrate (i.e., gravel, cobble, boulder); off-channel habitat; large woody debris; channel condition/dynamics; streambank condition; floodplain connectivity	Adults	Reduced forage and cover/shelter	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	All year
	Juveniles	Reduced forage and cover/shelter	From Hills Creek Dam tailrace to the upstream end of Lookout Point Reservoir (approx. 9 miles)	All year
Water contract administration	Juveniles	Reduced amount of rearing habitat	Points of diversion to confluence with Willamette River	July and August
		Mortality due to entrainment at diversions	Points of diversion	July and August 2008-2009
Hatchery RM&E *(see Table 11.1-4b)*				

Table 11.1-7 Estimates of the type and geographic and temporal extent of incidental take of UWR Chinook salmon associated with effects of the Willamette Project in the Calapooia, Molalla, and Clackamas subbasins.

FEATURE	LIFE STAGE(S)	TYPE OF TAKE	GEOGRAPHIC EXTENT	TEMPORAL EXTENT
Maintenance of revetments	Juveniles	Reduced amount of rearing	Molalla RM (upstream end of reach with USACE revetments) to confluence with the Willamette	All year

11.2 Reasonable & Prudent Measures

The following reasonable and prudent measures (RPM) and their related terms and conditions (T&C) are necessary and appropriate to minimize incidental take to the extent practicable and to monitor the incidental take of the ESA-listed species resulting from implementation of the PA and RPA. This includes continued operation and maintenance of the Willamette Project, maintenance of Project revetments, administration of Reclamation's water contract program, implementation of on-site and off-site mitigation measures, and operation of the Willamette Hatchery Mitigation Program. The RPMs and T&Cs are intended to avoid or minimize adverse effects of Project operations on listed fish species and on designated critical habitat.

USACE, Reclamation, and BPA must comply with all of the following reasonable and prudent measures and related terms and conditions, which are non-discretionary.

1) Minimize incidental take from general construction activities associated with implementation of the Proposed Action and RPA by applying best management practices to avoid or minimize adverse effects to listed species or to water quality, riparian habitat, or other aquatic system components of critical habitat.
2) Minimize incidental take from continued maintenance of revetments and from habitat restoration or mitigation activities by complying with the in-water work period and applying best management practices.
3) Minimize incidental take from general Research, Monitoring and Evaluation activities.
4) Ensure completion of a monitoring and reporting program to demonstrate compliance with the requirements of this ITS.
5) Minimize incidental take from operation of the Hatchery Mitigation Program

11.2.1 Terms and Conditions

In order to be exempt from the take prohibitions of Section 9 of the ESA and regulations issued pursuant to Section 4(d) of the ESA, the USACE, Reclamation, and BPA must carry out the following terms and conditions, which implement the RPMs listed above. These terms and conditions constitute no more than minor changes because they only provide further elaboration on the more general measures in the PA and RPA. These terms and conditions are non-discretionary. NMFS may amend the provisions of this ITS consistent with its statutory and regulatory authorities. Timely reporting of the results from Monitoring and Evaluation activities will help to identify the potential need to take such corrective action.

1) <u>Reasonable and prudent measure #1 implementation</u>: In all proposed actions involving construction in or near waterways, USACE, Reclamation, and BPA must ensure that best management practices for construction activities to control sediment, disturbance, and other potential detrimental effects to listed salmonids and critical habitat, described below, are followed.

a. Minimize areas impacted by construction. Construction impacts will be confined to the minimum area necessary to complete the project. Boundaries of clearing limits associated with site access and construction will be marked to avoid or minimize disturbance of riparian vegetation, wetlands and other sensitive sites.

b. Alteration or disturbance of the streambanks and existing riparian vegetation will be minimized to the greatest extent possible.

c. Mechanical removal of undesired vegetation and root nodes is permitted, but not herbicide use.

d. All existing vegetation within 150 ft of the edge of bank should be retained, to the greatest extent possible.

e. Timing of inwater work. Work below the bankfull elevation will be completed during the State of Oregon's preferred inwater work period as appropriate for the project area, unless otherwise approved in writing by NMFS. Other project specific requirements may apply (e.g., notification of NMFS prior to, or at the end of, inwater work) as identified during review of proposed project plans by NMFS.

f. Cessation of work. Construction project activities will cease under high flow conditions that may result in inundation of the project area, except for efforts to avoid or minimize resource damage. All materials, equipment, and fuel must be removed if flooding of the area is expected to occur within 24 hours.

g. Fish screens. All water intakes used for a construction project, including pumps used to isolate an inwater work area, will have a fish screen installed, operated, and maintained according to NMFS' fish screen criteria. This clause does not authorize screens for any permanent use.

h. Fish passage. Passage must be provided for any adult or juvenile salmonid species present in the Project area during construction, unless otherwise approved in writing by NMFS, and maintained after construction for the life of the Project. Passage will be designed in accordance with NMFS' "Anadromous Salmonid Passage Facility Design" (NMFS 2008e). Upstream passage is required during construction if it previously existed.

i. Construction activities associated with habitat enhancement and erosion control measures must meet or exceed best management practices and other performance standards contained in the applicable state and Federal permits.

j. Pollution and Erosion Control Plan. Prepare, in consultation with NMFS, and carry out a Pollution and Erosion Control Plan to prevent pollution caused by survey, construction, operation, and maintenance activities. The Plan will be available for inspection upon request by NMFS.

i. Plan Contents. The Pollution and Erosion Control Plan will contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

1. The name and address of the party(s) responsible for accomplishment of the Pollution and Erosion Control Plan.
2. Practices to prevent erosion and sedimentation associated with access roads, decommissioned roads, stream crossings, drilling sites, construction sites, borrow pit operations, haul roads, equipment and material storage sites, fueling operations, and staging areas.
3. Practices to confine, remove, and dispose of excess concrete, cement, and other mortars or bonding agents, including measures for washout facilities.
4. A description of any regulated or hazardous products or materials that will be used for the Project, including procedures for inventory, storage, handling, and monitoring.
5. A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.
6. Practices to prevent construction debris from dropping into any stream or water body, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.
7. Erosion control materials (e.g., silt fence, straw bales, aggregate) in excess of those installed must be available on site for immediate use during emergency erosion control needs.
8. Temporary erosion and sediment controls will be used on all exposed slopes during any hiatus in work exceeding 7 days.

ii. Inspection of erosion controls. During construction, the operator must monitor instream turbidity and inspect all erosion controls daily during the rainy season (October through May) and weekly during the dry season (June through September), or more often as necessary, to ensure the erosion controls are working adequately.[1]

1. If monitoring or inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs, install replacements, or install additional controls as necessary.

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[1] "Working adequately" means that project activities do not increase ambient stream turbidity by more than 10% above background 100 feet below the discharge, when measured relative to a control point immediately upstream of the turbidity-causing activity.

2. Remove sediment from erosion controls once it has reached one-third of the exposed height or capacity of the control.

k. Construction discharge water. Treat all discharge water created by construction (e.g., concrete washout, pumping for work area isolation, vehicle wash water, drilling fluids) as follows:

   i. Water quality. Design, build, and maintain facilities to collect and treat all construction discharge water, including any contaminated water produced by drilling, using the best available technology applicable to site conditions. Provide treatment to remove debris, nutrients, sediment, petroleum hydrocarbons, metals, and other pollutants likely to be present.

   ii. Discharge velocity. If construction discharge water is released using an outfall or diffuser port, velocities will not exceed 4 fps, and the maximum size of any aperture will not exceed one inch.

   iii. Spawning areas, submerged estuarine vegetation. Do not release construction discharge water within 300 ft upstream of spawning areas or areas with submerged estuarine vegetation. Clean construction discharge may be released.

   iv. Pollutants. Do not allow pollutants, including green concrete, contaminated water, silt, welding slag, sandblasting abrasive, or grout cured less than 24 hours to contact any wetland or the 2-year floodplain, except cement or grout when abandoning a drill boring or installing instrumentation in the boring.

   v. Drilling discharge. All drilling equipment, drill recovery and recycling pits, and any waste or spoil produced, will be completely isolated to prevent drilling fluids or other wastes from entering the stream.

      (1) All drilling fluids and waste will be completely recovered then recycled or disposed to prevent entry into flowing water.

      (2) Drilling fluids will be recycled using a tank instead of drill recovery/recycling pits, whenever feasible.

      (3) When drilling is completed, attempts will be made to remove the remaining drilling fluid from the sleeve (e.g., by pumping) to reduce turbidity when the sleeve is removed.

l. <u>Piling installation</u>: Install temporary and permanent pilings as depicted on NMFS-approved design drawings. Sound attenuation measures, including vibration dampeners, and unconfined or confined bubble curtains, will be used when impact driving steel pilings. Approval by NMFS of the measures is required before construction.

m. Piling removal: If a temporary or permanent piling will be removed from water containing fish, the following conditions apply.

   i. Dislodge the piling with a vibratory hammer.

   ii. Once loose, place the piling onto the construction barge or other appropriate dry storage site.

   iii. If a treated wood piling breaks during removal, either remove the stump by breaking or cutting 3 feet below the sediment surface or push the stump in to that depth, then cover it with a cap of clean substrate appropriate for the site.

n. During completion of habitat enhancement activities, no pollutants of any kind (sewage, waste spoils, petroleum products, etc.) should come in contact with the water body or wetlands nor their substrate below the mean high-high water elevation or 10-year flood elevation, whichever is greater.

o. Treated wood.

   i. Projects using treated wood that may contact flowing water or that will be placed over water where it will be exposed to mechanical abrasion or where leachate may enter flowing water will not be used, except for pilings installed following NMFS' guidelines.

   ii. Visually inspect treated wood before final placement to detect and replace wood with surface residues and/or bleeding of preservative.

   iii. Projects that require removal of treated wood will use the following precautions:

      1. Treated wood debris. Take care to insure that no treated wood debris falls into the water. If treated wood debris does fall into the water, remove it immediately.

      2. Disposal of treated wood debris. Dispose of all treated wood debris removed during a project, including treated wood pilings, at an upland facility approved for hazardous materials of this classification. Do not leave treated wood pilings in the water or stacked on the streambank.

p. Preconstruction activity. Complete the following actions before significant alteration of the Project area:

   i. Marking. Flag the boundaries of clearing limits associated with site access and construction to prevent ground disturbance of critical riparian vegetation, wetlands, and other sensitive sites beyond the flagged boundary. Construction activity or movement of equipment into existing vegetated areas must not begin until clearing limits are marked.

   ii. Emergency erosion controls. Ensure that the following materials for emergency erosion control are on site:

1. A supply of sediment control materials (e.g., silt fence, straw bales).

2. An oil-absorbing, floating boom whenever surface water is present.

iii. Temporary erosion controls. All temporary erosion controls will be in place and appropriately installed downslope of project activity within the riparian buffer area until site rehabilitation is complete.

q. Temporary access roads.

i. Steep slopes. Do not build temporary roads mid-slope or on slopes steeper than 30 percent.

ii. Minimizing soil disturbance and compaction. Low-impact, tracked drills will be walked to a survey site without the need for an access road. Minimize soil disturbance and compaction for other types of access whenever a new temporary road is necessary within 150 ft of a stream, water body, or wetland by clearing vegetation to ground level and placing clean gravel over geotextile fabric, unless otherwise approved in writing by NMFS.

iii. Temporary stream crossings.

1. Do not allow equipment in the flowing water portion of the stream channel where equipment activity could release sediment downstream, except at designated stream crossings.

2. Minimize the number of temporary stream crossings.

3. Design new temporary stream crossings as follows:

a) Survey and map any potential spawning habitat within 300 ft downstream of a proposed crossing.

b) Do not place stream crossings at known or suspected spawning areas, or within 300 ft upstream of such areas if spawning areas may be affected.

c) Design the crossing to provide for foreseeable risks (e.g., flooding and associated bedload and debris) to prevent the diversion of stream flow out of the channel and down the road if the crossing fails.

d) Vehicles and machinery will cross riparian buffer areas and streams at right angles to the main channel wherever possible.

4. Obliteration. When the project is completed, obliterate all temporary access roads, stabilize the soil, and revegetate the site. Abandon and restore temporary roads in wet or flooded areas by the end of the inwater work period.

r. Vehicles and heavy equipment. Restrict use of heavy equipment as follows:

   i. Choice of equipment. When heavy equipment will be used, the equipment selected will have the least adverse effects on the environment (e.g., minimally sized, low ground pressure equipment).

   ii. Vehicle and material staging. Store construction materials and fuel, operate, maintain, and store vehicles as follows:

      1. To reduce the staging area and potential for contamination, ensure that only enough supplies and equipment to complete a specific job will be stored on-site.

      2. Complete vehicle staging, cleaning, maintenance, refueling, and fuel storage, except for that needed to service boats, in a vehicle staging area placed 150 ft or more from any stream, water body, or wetland, unless otherwise approved in writing by NMFS.

      3. Inspect all vehicles operated within 150 ft of any stream, water body, or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by NMFS.

      4. Before activities begin and as often as necessary during construction activities, steam clean all equipment that will be used below the bankfull elevation until all visible external oil, grease, mud, and other visible contaminates are removed. Any washing of equipment must be conducted in a location that will not contribute untreated wastewater to any flowing stream or drainage area.

      5. Diaper all stationary power equipment (e.g., generators, cranes, stationary drilling equipment) operated within 150 ft of any stream, waterbody, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream, water body, or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream or water body.

      6. At the end of each work shift, vehicles must not be stored within or over the waterway.

s. Site preparation. Conserve native materials for site rehabilitation.

   i. If possible, leave native materials where they are found.

   ii. If materials are moved, damaged, or destroyed, replace them with a functional equivalent during site rehabilitation.

   iii. Stockpile any large wood, native vegetation, weed-free topsoil, and native channel material displaced by construction for use during site rehabilitation.

t. Isolation of inwater work area. If adult or juvenile fish are reasonably certain to be present, or if the work area is less than 300 ft upstream of spawning habitats, completely isolate the work area from the active flowing stream using inflatable bags, sandbags, sheet pilings, or similar materials, unless otherwise approved in writing by NMFS.

u. Capture and release of fish in construction salvage operations. Before and intermittently during pumping to isolate an inwater work area, attempt to capture fish from the isolated area using trapping, seining, electrofishing, or other methods as are prudent to minimize risk of injury, then release them at a safe and suitable release site.

   i. The entire capture and release operation will be conducted or supervised by a fishery biologist experienced with work area isolation and competent to ensure the safe handling of all ESA-listed fish.

   ii. If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000c) and summarized below.

      1. Do not electrofish near adult salmon in spawning condition or near redds containing eggs.

      2. Keep equipment in good working condition. Complete manufacturers' preseason checks, follow all provisions, and record major maintenance work in a log.

      3. Train the crew by a crew leader with at least 100 hours of electrofishing experience in the field using similar equipment. Document the crew leader's experience in a logbook. Complete training in waters that do not contain listed fish before an inexperienced crew begins any electrofishing.

      4. Measure conductivity and set voltage as follows:

Conductivity (µS/cm)	Voltage
Less than 100	900 to 1100
100 to 300	500 to 800
Greater than 300	150 to 400

      5. Use direct current (DC) at all times.

      6. Begin each session with pulse width and rate set to the minimum needed to capture fish. These settings should be gradually increased only to the point where fish are immobilized and captured. Start with a pulse width of 500µs and do not exceed 5 milliseconds. Pulse rate should start at 30Hz and work carefully upward. In general, pulse rate should not exceed 40 Hz, to avoid unnecessary injury to the fish.

7. The zone of potential fish injury is 0.5 meters from the anode. Care should be taken in shallow waters, undercut banks, or where fish can be concentrated, because in such areas the fish are more likely to come into close contact with the anode.

8. Work the monitoring area systematically, moving the anode continuously in a herringbone pattern through the water. Do not electrofish one area for an extended period.

9. Have crew members carefully observe the condition of the sampled fish. Dark bands on the body and longer recovery times are signs of injury or handling stress. When such signs are noted, the settings for the electrofishing unit may need adjusting. End sampling if injuries occur or abnormally long recovery times persist.

10. Whenever possible, place a block net below the area being sampled to capture stunned fish that may drift downstream.

11. Record the electrofishing settings in a logbook along with conductivity, temperature, and other variables affecting efficiency. These notes, with observations on fish condition, will improve technique and form the basis for training new operators.

iii. Do not use seining or electrofishing if water temperatures exceed 18°C unless no other more suitable and effective method of capture is available.

iv. Handle ESA-listed fish with extreme care, keeping fish in water to the maximum extent possible during seining and transfer procedures, to prevent the added stress of out-of-water handling.

v. Transport fish by providing circulation of clean cold water in aerated buckets, tanks, or in sanctuary nets that hold water during transfer. Minimize holding times.

vi. Release fish into a safe and appropriate release site as quickly as possible, and as near as possible to the original capture sites.

vii. Do not transfer ESA-listed fish to anyone except NMFS personnel, unless otherwise approved in writing in advance of the transfer.

viii. Obtain all other Federal, state, and local permits necessary to conduct the capture and release activity.

ix. Allow NMFS or its designated representative to accompany the capture team during the capture and release activity, and to inspect the team's capture and release records and facilities.

x. An electronic copy of the Salvage Report Form is submitted to NMFS within 10 calendar days of completion of the salvage operations, noting the quantities and species of fish salvaged.

xi. Fish salvage operations must be re-conducted should the isolated construction areas be temporarily hydraulically re-connected to the adjacent waterway, such as after a high-water event or cofferdam failure.

v. Earthwork. Complete earthwork (including drilling, excavation, dredging, filling, and compacting) as quickly as possible.

i. Excavation. Material removed during excavation will only be placed in locations where it cannot enter sensitive aquatic resources. Whenever topsoil is removed, it must be stored and reused on site to the greatest extent possible. If riprap is used for protecting a culvert inlet or outlet, it will be class 350 metric or larger, and topsoil will be placed over the rock and planted with native woody vegetation.

ii. Drilling and sampling. If drilling, boring, or jacking is used, the following conditions apply.

1. Isolate drilling operations from stream channels using a steel pile, sleeve, or other appropriate isolation method to prevent drilling fluids from contacting water.

2. If it is necessary to drill through a bridge deck, use containment measures to prevent drilling debris from entering the stream channel.

3. If directional drilling is used, the drill, bore, or jack hole will span the channel migration zone and any associated wetland or wetted stream channel.

4. Sampling and directional drill recovery/recycling pits, and any associated waste or spoils, will be completely isolated from surface waters, off-channel habitats, and wetlands. All drilling fluids and waste will be recovered and recycled or disposed of to prevent future entry into flowing water.

5. If a drill boring conductor breaks and drilling fluid or waste is visible in water or a wetland, all drilling activity will cease, pending written approval from NMFS to resume drilling.

iii. Site stabilization. Stabilize all disturbed areas, including obliteration of temporary roads, following any break in work, unless construction will resume within 4 days.

iv. Source of materials. Obtain boulders, rock, woody materials, and other natural construction materials used for the project outside the riparian buffer area. Spawning gravel for augmentation of spawning habitats must be washed (i.e. cleaned, rinsed rock) river rock, of suitable size for UWR spring Chinook spawning or for UWR winter steelhead spawning (as appropriate by location), and if possible, from a source within the local watershed.

w. Stormwater management: Prepare and carry out a stormwater management plan for any project that will produce a new impervious surface or a land cover conversion that slows the entry of water into the soil. The plan must be available for inspection on request by NMFS.

  i. Plan contents. The goal is to avoid and minimize adverse effects due to the quantity and quality of stormwater runoff for initial construction, and throughout the life of the project by maintaining or restoring natural runoff conditions. The plan will meet the following criteria and contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

    1. A system of management practices and, if necessary, structural facilities, designed to complete the following functions:

      a. Minimize, disperse and infiltrate stormwater runoff onsite using sheet flow across permeable vegetated areas to the maximum extent possible without causing flooding, erosion impacts, or long-term adverse effects to groundwater.

      b. Pretreat stormwater from pollution generating surfaces, including bridge decks, before infiltration or discharge into a freshwater system, as necessary to minimize any nonpoint source pollutant (e.g., debris, sediment, nutrients, petroleum hydrocarbons, metals) likely to be present in the volume of runoff predicted from a 6-month, 24-hour storm.

    2. Document completion of the following storm water management activities according to a regular schedule for the operation, inspection and maintenance of all structural facilities and conveyance systems, in a log available for inspection on request by NMFS.

      a. Inspect and clean each facility as necessary to ensure that the design capacity is not exceeded, heavy sediment discharges are prevented, and whether improvements in operation and maintenance are needed.

      b. Promptly repair any deterioration threatening the effectiveness of any facility.

      c. Post and maintain a warning sign on or next to any storm drain inlet that says, as appropriate for the receiving water, 'Dump No Waste - Drains to Ground Water, Streams, or Lakes.'

d. Only dispose of sediment and liquid from any catch basin in an approved facility.

ii. Runoffs/discharge into a freshwater system. When stormwater runoff will be discharged directly into fresh surface water or a wetland, or indirectly through a conveyance system, the following requirements apply.

1. Maintain natural drainage patterns and, whenever possible, ensure that discharges from the project site occur at the natural location.

2. Use a conveyance system comprised entirely of manufactured elements (e.g., pipes, ditches, outfall protection) that extends to the ordinary high water line of the receiving water.

3. Stabilize any erodible elements of this system as necessary to prevent erosion.

4. Do not divert surface water from, or increase discharge to, an existing wetland if that will cause a significant adverse effect to wetland hydrology, soils or vegetation.

5. The velocity of discharge water released from an outfall or diffuser port may not exceed 4 feet per second.

6. Waste anesthetic-laden water must be disposed of in accordance with applicable laws.

x. Implementation monitoring. For projects undertaken by or funded by USACE, Reclamation, or BPA, the USACE, Reclamation, or BPA will include the status of a project or a description of the completed project in the annual report. This annual report will be submitted to NMFS describing the status of projects and, if completed, the success in meeting the RPMs and associated terms and conditions of the Opinion. It will include the following:

i. Project identification.

1. Project implementer name, project name, detailed description of the project.

2. Project location by 5th or 6th field HUC and by latitude and longitude as determined from the appropriate U.S. Geological Survey 7-minute quadrangle map.

3. Starting and ending dates for the work completed, or expected completion date for ongoing projects.

ii. Photo documentation. Photo documentation of habitat conditions at the project site before, during, and after project completion.

1. Include general views and close-ups showing details of the project and project area, including pre- and post-construction.

2. Label each photo with date, time, project name, photographer's name, and documentation of the subject activity.

iii. Other data. Additional project-specific data, as appropriate, for individual projects:

1. Work cessation. Dates work ceased because of high flows, if any.

2. Fish screen. Compliance with NMFS' fish screen criteria.

3. Pollution and Erosion Control Plan. A summary of pollution and erosion control inspections, including any erosion control failures, contaminant releases, and correction efforts.

4. Description of site preparation.

5. Isolation of inwater work area, capture, and release.

   a) Supervisory fish biologist's name and address.

   b) Methods of work area isolation and take minimization.

   c) Stream conditions before, during, and within 1 week after completion of work area isolation.

   d) Means of fish capture.

   e) Number of fish captured by species.

   f) Location and condition of all fish released.

   g) Any incidence of observed injury or mortality of listed species.

6. Streambank protection.

   a) Type and amount of materials used.

   b) Project size - one bank or two, width, and linear feet.

7. Site rehabilitation. Photo or other documentation that site rehabilitation performance standards were met.

NMFS will be reviewing the detailed construction plans submitted to advise USACE, Reclamation, or BPA regarding whether or not those plans are likely to meet the "best management practices" articulated in this incidental take statement's terms and conditions, or such additional best management practices that NMFS deem appropriate.

2) Reasonable and prudent measure #2 implementation: The Action Agencies will comply with the following conditions related to the maintenance of revetments and to habitat restoration or mitigation activities in the Willamette River Basin.

   a. In water work period. All work within the wetted channel will be completed during periods of time listed in the Oregon Guidelines (ODFW 2000b)except that the winter work window is not approved for projects in the Willamette River below Willamette Falls. Also, hydraulic and topographic measurements may be completed at any time, provided that the affected area is not occupied by adult fish congregating for spawning or an area where redds are occupied by eggs or preemergent alevins. The guidelines are available from the ODFW, Wildlife Division, Salem, Oregon.

   b. Work Area Isolation. Any activity resulting in work within the wetted channel will be completely isolated from the active stream whenever a fish is reasonably certain to be present, or if the work area is 300 feet or less upstream from spawning habitats.

   c. Work Area Isolation Plan. When work area isolation is required, a work area isolation plan will be prepared and carried out, commensurate with the scope of the project, that includes: (a) The name, phone number, and address of the person responsible for accomplishing each component of the plan; (b) an estimate of stream flows likely to occur during isolation; (c) a plan view of all isolation elements and fish release areas; (d) a list of equipment and materials necessary to complete the plan, including a fish screen for any pump used to dewater the isolation area; (e) and the sequence and schedule of dewatering and rewatering activities. Pile driving may occur without isolation during the in-water work period, provided that hydro-acoustic sound pressure attenuation requirements and all other relevant conservation measures are met.

   d. Work from top of bank. To the extent feasible, heavy equipment will work from the top of the bank, unless work from another location would result in less habitat disturbance.

   e. Site restoration. Any large wood, native vegetation, topsoil, and native channel material displaced by construction will be stockpiled for use during site restoration. When construction is finished, all streambanks, soils, and vegetation will be cleaned up and restored as necessary to renew ecosystem processes that form and maintain productive fish habitats. Fencing will be installed as necessary to prevent access to revegetated sites by livestock or unauthorized persons.

   f. Plant willows or other trees on 3’ centers in rock interstices on all revetments whenever maintenance activities occur. These plantings will be maintained and allowed to freely grow. No mowing of vegetation and no new revetments are allowed under this consultation. If the Corps opts to not vegetate revetments, they shall enhance adjacent riparian areas at a 5:1 linear ratio (i.e. for a 100’ of revetment, 500’ of riparian area will be enhanced from one site potential tree height measured outward from top of bank, and extending down the bank to the line of no plant growth) or remove riprap from the stream at a 2:1 ratio (i.e. for every 100' of rock replaced, 200' will be removed.)

g. For habitat enhancement actions, the Corps shall follow the terms and conditions set forth in the incidental take statement of the SLOPES IV Restoration Biological Opinion (NMFS 2008f).

3) <u>Reasonable and prudent measure #3 implementation:</u> The Action Agencies will comply with the following conditions that relate to the implementation of research, monitoring, and evaluation studies identified in the PA and RPA.

a. All Monitoring and Evaluation plans associated with anadromous fish developed under the PA and RPA must meet NMFS' satisfaction and must be agreed to by NMFS. Work will be conducted by USACE, Reclamation, BPA, or their contractors. To ensure that the monitoring and evaluation plan will provide a benefit to listed species, and provide useful information on the effectiveness of various aquatic measures as well as achievement of fish passage goals, USACE, Reclamation, and BPA will develop plan(s) and methods to monitor aspects of the various aquatic measures, including:

- Flow management
- Fish passage
- Adult anadromous salmonid migration, spawning, distribution & abundance
- Water quality
- Hatchery mitigation programs
- Habitat restoration
- Resident fish species

The USACE, Reclamation, and BPA's plan(s), among other items, will thoroughly describe all methods that will be used to capture fish and how fish will be handled; details such as sampling locations and dates; and any use of invasive procedures such as tagging, taking tissue samples, or sacrifice of fish explaining the necessity and purpose of each procedure. Each plan will include estimates of the number of each species and life stage that will be handled and/or killed for that study. In addition, the plans will include methods by which they will be modified if empirical evidence indicates that negative effects on a species/life stage are greater than expected. USACE, Reclamation, and BPA will provide NMFS with annual reports, which they will use to determine whether or not to authorize the next year's work under a multiyear plan. NMFS must approve all plans in writing before they are implemented.

The USACE, Reclamation, and BPA will make the following terms and conditions a conditional part of any contractual arrangement or other agreement made with other parties regarding the conduct of research, monitoring, and evaluation studies approved for implementation by NMFS under the auspices of this ITS.

b. Workers[2] must ensure that listed species are taken only at the levels, by the means, in the areas, and for the purposes stated in each specific monitoring and evaluation proposal, and according to the conditions in this permit.

c. Workers must not intentionally kill or cause to be killed any listed species unless a specific monitoring or evaluation proposal, reviewed and agreed to by NMFS, specifically allows intentional lethal take.

d. Workers must handle listed fish with extreme care and keep them in appropriately cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the researcher must process listed fish first to minimize handling stress.

e. Workers must stop handling listed juvenile fish if the water temperature exceeds 70° F at the capture site. Under these conditions, listed fish may only be visually identified and counted.

f. If workers anesthetize listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

g. Workers must use a sterilized needle for each individual injection when PIT-tags are inserted into listed fish.

h. If workers incidentally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

i. If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000c), and as described in Condition #2.u above (electrofishing conditions for salvage).

j. Except for escapement (redd) surveys, no in-water work will occur within 300 feet of spawning areas during anadromous fish spawning and incubation times.

k. Persons conducting redd surveys will be trained in redd identification, likely redd locations, and methods to minimize the likelihood of stepping on redds or delivering fine sediment to redds.

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[2] "Workers" in this context refers to researchers, technicians, consultants, volunteers, and employees of the Action Agencies, Services, or other organization authorized to conduct RM&E as part of this Opinion.

l. Workers will avoid redds and listed spawning fish while walking within or near stream channels to the extent possible. Avoidance will be accomplished by examining pool tail outs and low gradient riffles for clean gravel and characteristic shapes and flows prior to walking or snorkeling through these areas.

m. If redds or listed spawning fish are observed at any time, workers will step out of the channel and walk around the habitat unit on the bank at a distance from the active channel.

n. Snorkel surveys will follow a statistically valid sampling design or rely on a single pass approach.

o. Surveyors will coordinate with other local agencies to prevent redundant surveys.

p. Excavated material from cultural resource test pits will be placed away from stream channels. All material will be replaced back into test pits when testing is completed.

q. Multiple stream sites will be used for field trips to minimize effects on any given stream or riparian buffer area.

r. The Action Agencies must obtain approval from NMFS before changing sampling locations or research protocols.

s. The Action Agencies must notify NMFS as soon as possible but no later than 2 days after any authorized level of take is exceeded or if such an event is likely. The Action Agencies must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

t. The Action Agencies are responsible for any biological samples collected from listed species as long as they are used for research purposes. The Action Agencies may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

u. Workers actually doing the evaluation must carry a copy of this ITS and the applicable plan while conducting the authorized activities.

v. Workers must allow any NMFS employee or representative to accompany field personnel while they conduct the evaluation activities.

w. Workers must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

x. Workers must obtain all other Federal, state, and local permits/authorizations needed for the evaluation activities.

y. Every year, the Action Agencies must submit to NMFS a post-season report describing the evaluation activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the monitoring results. This report may be included in the annual report identified in the RPA and required by this ITS. Falsifying annual reports or permit records is a violation of this ITS.

z. If workers violate any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA findings are no longer valid.

4) To implement reasonable and prudent measure #4, USACE, Reclamation, and BPA must complete all monitoring and reporting requirements in the RPA and Proposed Action. They must also report all observations of dead or injured salmon or steelhead adults or juveniles coincident with carrying out the terms and conditions of the above measures (noting whenever possible the species of these individuals) to NMFS within 2 days of their observance, and include a concise description of the causative event (if known), and a description of any resultant corrective actions taken (if any) to reduce the likelihood of future mortalities or injuries. Reports of dead or injured salmon or steelhead should be sent to:

Willamette Project Staff Lead
Hydropower Division
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, Oregon 97232
(503) 736-4720

5) Reasonable and prudent measure #5 implementation: The Action Agencies will comply with the following conditions that relate to the continued operation of the Hatchery Mitigation Program as described in the PA, HGMPs, and the RPA.

a. The Action Agencies (in cooperation with ODFW) shall manage all of the artificial propagation programs as described in the Biological Assessment and the submitted Hatchery and Genetic Management Plans. NMFS (Salmon Recovery Division) must be notified prior to any change in the proposed management or operation of the programs.

b. The Action Agencies (in cooperation with ODFW) must ensure that listed species are taken only at the levels, by the means, in the areas, and for the purposes stated in the Biological Assessment, HGMPs, and the RPA. However, hatchery program management objectives can be adaptively managed based upon the latest scientific and monitoring information as long as authorized take levels of natural-origin fish are not exceeded. Hatchery program management changes that result in lower take levels of listed, natural-origin fish are acceptable, if future information shows the management change is warranted.

c. In the event that circumstances, such as unanticipated, higher-than-expected fecundity, or high egg-to-fry survival rates, lead to the inadvertent possession of salmon or steelhead substantially in excess (>110 percent) of program production levels specified above, then NMFS (Salmon Recovery Division) must be notified immediately to determine future actions, unless specific actions for addressing excess production are provided in the HGMP

d. All hatchery management and monitoring and evaluation reports shall be submitted to NMFS at:

Willamette Hatchery Staff Lead
Salmon Recovery Division
National Marine Fisheries Service
1201 N.E. Lloyd Blvd, Suite 1100
Portland, Oregon 97232
Phone: (503) 736-4737

e. The Action Agencies (in cooperation with ODFW) must notify the Salmon Recovery Division of NMFS as soon as possible, but no later than two days, after any authorized level of take is exceeded or if such an event is likely. The Action Agencies (in cooperation with ODFW) must submit a written report detailing why the authorized take level was exceed or is likely to be exceeded.

f. The Action Agencies (in cooperation with ODFW) shall update and provide to the Salmon Recovery Division of NMFS by December 15th of each year the projected hatchery releases by age class and location for the coming year.

Chapter 12
Conservation Recommendations

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12 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary measures that NMFS believes are consistent with an Action Agencies' obligation.

NMFS recommends that the Action Agencies carry out the following conservation measures:

12.1 LAMPREY & RESIDENT FISH SPECIES

Consider the needs of Pacific lamprey and native resident fish species in the design and construction of upstream and downstream fish passage and fish sampling facilities associated with the Willamette Project. Passage investigations at each project should consider lamprey passage as well as salmonid passage.

All flow and water quality related operations and structural modifications, whether experimental or standard, should fully take into account potential negative and positive effects on lamprey. The Action Agencies should use latest scientific information to consider how the operations or modifications are neutral or positive for meeting lamprey requirements at all life-history stages and should include measures to evaluate the effects of these operations and structural modifications on lamprey. The Action Agencies should identify existing or develop and implement new lamprey specific research and monitoring activities in consultation with appropriate Tribes and in potential partnerships with others in the basin.

Water withdrawal facilities operated with Reclamation water storage contracts as well as those associated with Willamette Project hatcheries and other Willamette Project facilities should employ structures and operations that avoid negative impacts on lamprey.

12.2 SYSTEM OPERATIONS ANALYSIS

Review existing Project operating criteria and the information used to develop them. If the Action Agencies, with review by WATER and the Services, determine that currently available data and techniques might improve the Corps' ability to meet the flow objectives specified in this Opinion while meeting current flood control objectives, then the Action Agencies should undertake a detailed systems operations analysis, identify operating criteria that meet these objectives, and implement such changes as soon as possible.

Willamette system water management objectives for listed salmonids should be analyzed in a Basin-wide assessment, which considers alternatives to improve the percentage of time that such objectives are attained. Such analysis should consider the effects of alternative flood control operations, improved forecasting procedures, climate change scenarios, improved water quality and other water management strategies that specifically benefit anadromous fish. Beneficial changes from the review should be incorporated into modified management of the Willamette River projects.

Willamette Project seasonal drafting and refilling operations designed to provide storage space to control floods and to refill project reservoirs for summer recreation may at times limit the potential to operate the projects in a manner beneficial to salmon and steelhead. These operating criteria were developed several decades ago, before information on the flow needs for fish were developed and prior to recent improvements in weather and streamflow predictive capacity and climate change. It is likely that project operations could be modified in ways that would have negligible effects on flood risks while providing substantial benefits to fish. In order to identify such changes in project operations, it may be necessary to conduct a detailed systems operations analysis that would use up-to-date predictive modeling, climate change information, and fish flow needs.

12.3 LEABURG SORTING FACILITIES

Construct sorting facilities at Leaburg Dam on the McKenzie River as soon as possible.

This recommendation would supplement RPA measure #6.1.4, in section 9.6 of this Opinion. The RPA measure requires the Action Agencies to complete construction of a sorting facility to reduce hatchery fish straying into core Chinook salmon natural production habitat upstream by December 2013. NMFS recommends that the Action Agencies make every effort to complete this high priority facility by 2011. Efforts are already underway to secure permission from the dam owner, Eugene Water & Electric Board, to install a sorting facility for one or both of the ladders at the dam.

12.4 INTERIM TEMPERATURE CONTROL

Carry out interim temperature management at Foster/Green Peter, Dexter/Lookout Point, Hills Creek, and Blue River beginning in spring 2009, or as soon as possible, as determined by feasibility analyses.

As noted in Section 9.5, interim measures might be feasible at Project dams to provide some level of temperature control similar to that provided by the Cougar Water Temperature Control facilities in the McKenzie River subbasin. Experience at Detroit/Big Cliff in the North Santiam River following a powerhouse fire in 2007 showed that by mixing discharge from spill and the regulating outlet, flows below Big Cliff dam could more closely approximate normative water temperatures than under typical Project operations. RPA measure 5.1.1 requires the Action Agencies to carry out interim temperature control at Detroit/Big Cliff, if feasible. In addition, RPA measure 5.1.2 requires the Action Agencies to carry out temperature control at other Project dams by April, 2010, if feasible. The purpose of this conservation measure is to achieve interim temperature management earlier than April, 2010, carrying out these actions sooner than required in RPA 5.1.1.

Lookout Point Dam is a priority for evaluation for both temperature control and downstream passage because monitoring shows extremely high egg mortality for UWR Chinook salmon in the very limited spawning habitat below Dexter Dam (see Middle Fork Willamette Effects section 5.2). Hills Creek Dam is another location that would likely provide immediate improvements in fish spawning and rearing habitat in the Middle Fork Willamette River below the dam downstream to the upper limit of Lookout Point reservoir.

12.5 HABITAT RESTORATION PROJECTS

Identify and carry out extensive habitat restoration projects, including protection of high value aquatic habitats through land purchase or conservation easements, in the mainstem Willamette and tributaries to address habitat-related limiting factors for UWR Chinook salmon and steelhead. Use the programs and authorities described in Tables 9.7.1 and 9.7.2 (or any other applicable authorities, programs, or funding sources) to seek partnerships to maximize benefits with other Federal, State, and Tribal programs and through watershed councils and other partners.

In section 9.7 of the Opinion, RPA measures 7.1 and 7.2 require the Action Agencies to develop habitat restoration programs and begin to carry out projects by 2010. NMFS recommends that these programs begin as soon as possible, rather than waiting until 2010, and that sufficient funds be allocated to this effort to achieve measurable habitat improvements. NMFS describes in the baseline and effects chapters 4 and 5, respectively, how much of the complex rearing habitat in the mainstem Willamette and lower reaches of the tributaries has been lost due to revetments, flood control, and other land use development. Until UWR Chinook salmon and steelhead can pass safely upstream and downstream past Project dams, productivity and abundance of these species must rely on protecting and restoring downstream habitat.

Much work has already been completed on identifying and prioritizing key aquatic habitat restoration objectives in the "Willamette River Basin Planning Atlas" (Hulse et al. 2002). In particular, Chapter 8 of this Planning Atlas entitled "River Restoration" describes restoration priorities of 1) restoring channel complexity, and 2) protecting and restoring floodplain forests. The habitat restoration program described in this Biological Opinion should incorporate the work of Hulse et al. (2002) in considering the prioritization and funding of projects. The candidate reaches identified as "high ecological potential and low demographic and social constraints" by Hulse et al. (2002) should be the highest priority areas for potentially implementing restoration projects.

12.6 TRIBAL PARTICIPATION IN IMPLEMENTATION ACTIVITIES

The Action Agencies should invite appropriate Tribes to seek contracts to assist in performing activities related to investigating the feasibility of fish passage at Project dams. The Action Agencies, as well as other Federal agencies who will manage contracts for this work, should initiate a discussion with each appropriate Tribe to determine their desire to participate in the work and to identify mechanisms to provide funding for Tribal involvement where desired and appropriate.

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Chapter 13
Essential Fish Habitat Consultation

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13 ESSENTIAL FISH HABITAT CONSULTATION

13.1 BACKGROUND

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. §§ 1801-1884, includes requirements to identify, conserve, and enhance essential fish habitat (EFH) for those species regulated under a Federal fisheries management plan. EFH is defined in the MSA as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. NMFS further elaborates on this definition in its EFH regulations and states that: waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR 600.10). "Adverse effect" means any impact which reduces quality and/or quantity of EFH, and may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey or reduction in species fecundity), site-specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

Federal agencies must consult with NMFS on agency actions, or proposed actions that may adversely affect EFH, including actions that occur outside EFH, such as certain upstream and upslope activities. NMFS provides EFH conservation recommendations for any Federal or State action that would adversely affect EFH (§305(b)(4)(A)). The EFH conservation recommendations are measures to avoid, minimize or otherwise offset adverse impacts to EFH. Federal agencies must provide a detailed response in writing to NMFS within 30 days after receiving EFH conservation recommendations. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS' EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations (§305(b)(4)(B)).

13.2 IDENTIFICATION OF EFH

Pursuant to the MSA, the Pacific Fisheries Management Council has designated EFH for three species of federally managed Pacific salmon: Chinook salmon (Oncorhynchus tshawytscha); coho (*O. kisutch*); and Puget Sound pink salmon (O. gorbuscha) (PFMC 1999). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable manmade barriers (as identified by the PFMC 1999) and longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years). [1] In estuarine and marine areas, Pacific salmon EFH extends from the nearshore

[1] The PMFC has determined that the following Willamette Project dams define the upstream limit of EFH: Big Cliff, Cougar, Dexter, and Dorena.

and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California north of Point Conception to the Canadian border. Detailed descriptions and identifications of EFH for salmon are found in Appendix A to Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS' assessment of potential adverse effects to these species' EFH from the proposed action is based, in part, on this information. This consultation addresses adverse effects on EFH for Chinook and coho salmon.

EFH for groundfish and coastal pelagic species encompasses all waters from the mean high water line, and upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon, and California, and seaward to the boundary of the U.S. exclusive economic zone (PFMC 1998a, 1998b). Detailed descriptions and identifications of these EFH designations are contained in the fishery management plans for groundfish (PFMC 1998a) and coastal pelagic species (PFMC 1998c). Casillas et al. (1998b) provide additional detail on the groundfish EFH habitat complexes. NMFS has identified seven groundfish habitat complexes (estuarine, rocky shelf, non-rocky shelf, neritic zone, oceanic zone, continental slope/break and canyon) and identified species that may occur in each of those areas. The estuarine complex, which (with the neritic zone) is pertinent to this consultation, includes those waters, substrates and associated biological communities within bays and estuaries of the Exclusive Economic Zone[2], from mean higher high water level (MHHW) or extent of upriver saltwater intrusion to the respective outer boundaries for each bay or estuary, as defined in 33 CFR 80.1 (Coast Guard lines of demarcation). The neritic zone is the relatively shallow ocean that extends from the outer edge of the intertidal zone to the edge of the continental shelf. It therefore contains the Columbia River plume. Two groundfish and two coastal pelagic species occur within the action area for the proposed action (Table 13-1).

Table 13-1 Non-salmonid fish species with EFH in the action area for operations & maintenance of the Willamette Project. Sources: Casillas 1998b and Emmett et al 1991

Species	Habitat Preferences
Starry Flounder *Platichthys stellatus*	Mud, sand; often found in estuaries and upstream in freshwater
English sole *Pleuronectes vetulus*	Sand, Mud
Northern Anchovy *Engraulis mordax*	Pelagic
Pacific Sardine *Sardinops sagax*	Pelagic

[2] The Exclusive Economic Zone extends 200 miles off the U.S. coastline.

13.3 Proposed Action

The proposed action under consideration in this EFH consultation includes the Reasonable and Prudent Action (RPA) measures (Chapter 9) combined with PA described in Chapter 2 of the accompanying Biological Opinion (RPA/PA). The RPA/PA affects EFH in portions of the states of Oregon and Washington, and the Columbia River estuary and plume.

Affected portions of the Willamette and Columbia rivers and several affected Willamette basin tributaries serve as migratory corridors for anadromous salmonids, including Chinook and coho salmon. Portions of affected Willamette basin tributaries also serve as spawning and rearing habitats for Chinook and coho salmon.[3] The RPA/PA affects flow in areas of the Columbia River estuary and plume used by the two species of groundfish (starry flounder and English sole) and two coastal pelagic species (northern anchovy and Pacific sardine) for which EFH is also designated.

13.4 Effects of Proposed Action on EFH

As described in Chapter 4, Environmental Baseline and Chapter 5, Effects of the Proposed Action of the Biological Opinion, the proposed operations and maintenance of the Willamette Project may result in short- and long-term impacts, both positive and negative, to a variety of habitat parameters. The adverse impacts to EFH for the unlisted Chinook and coho salmon species are the same as those described for the ESA-listed salmonids. Therefore, the ESA effects analysis in the Biological Opinion (Chapter 5) addresses impacts of the PA to salmon EFH. As described in the following sections, the RPA/PA is likely to adversely affect salmon EFH.

Effects on groundfish and coastal pelagic species EFH are described below.

13.4.1 Effects on Mainstem Habitat Conditions, Including the Estuary & Plume

13.4.1.1 Habitat Blockage Effects

Several of the high-head water storage facilities included in the RPA/PA were developed without fish passage facilities, and where fish passage was provided, it functions poorly. Roughly 70 to 80 percent of the spawning and rearing habitats historically available to Chinook salmon in the North and South Santiam rivers, the McKenzie River, and the Middle Fork Willamette River have been blocked by dams (see Chapter 4 of the Biological Opinion). This reduction in accessible habitats is considered a primary contributing factor in the decline of Willamette basin Chinook salmon (NMFS 1998). Conversely, coho salmon were not known to use the Willamette River, or its tributaries, upstream from Willamette Falls and were introduced into watersheds upstream of the falls in the 1950s following installation of adult fish passage facilities at

[3] Historically, few if any coho salmon ascended Willamette Falls. Currently, the Tualatin River population is the only coho population upstream from Willamette Falls. Coho are thus only affected by the PA/RPA from the confluence of the Willamette and Tualatin rivers downstream to the mouth of the Columbia River and the Columbia River plume.

hydroelectric projects located at the Falls. Of these introductions, only the Tualatin River population remains viable.

The PFMC (1999) determined that several Willamette Project dams are the upstream termini of EFH on their respective tributary streams. Historically accessible habitats upstream from Big Cliff, Cougar, Dexter, and Dorena dams are therefore not EFH. Historically accessible habitats on the South Santiam upstream from Foster and Green Peter dams, and historically accessible habitats on Fall Creek upstream from Fall Creek are EFH. Fish passage conditions at these dams remains poor to non-existent, adversely affecting the utility of this EFH.

13.4.1.2 Water Management Effects

Coho & Chinook Salmon

As described in Chapter 5 of the Biological Opinion, the RPA/PA would cause a net reduction in spring flows (April-June) in the mainstem Willamette River through which both Chinook and coho salmon migrate, and in several of its tributaries occupied by Chinook salmon. In the lower Columbia River, the RPA/PA would reduce spring flows by about 2% (Opinion Table 4.11-2). These flow reductions likely reduce the survival of UWR Chinook[4] and may slightly affect survival of other Chinook and coho populations that migrate through the Columbia River migratory corridor during the spring (e.g. SR spring/summer Chinook salmon, UCR spring Chinook salmon, some populations of LCR Chinook salmon, and MCR spring Chinook salmon).

The RPA/PA also increases flows during the summer and fall as the reservoirs are drafted. Available data suggests that summer flow increases would improve the survival of ocean-type Chinook juveniles migrating through the lower Columbia River during the summer. This would benefit the unlisted UCR summer/fall Chinook and SR fall Chinook. Improved fall flows in the occupied sections of the Willamette basin tributaries downstream from project dams, and the control of flow fluctuations, would improve spawning habitat conditions for UWR Chinook and may benefit non-native fall Chinook that spawn or rear in the Willamette basin.

Two sets of authors recently evaluated the sensitivity of the amount and distribution of shallow-water rearing habitat in the lower Columbia River (i.e., Hyde et al. 2004 for conditions in RMs 0-35; Jay et al. 2004 for RMs 35-55) to changes in discharge at Bonneville Dam during summer (i.e., July through September). Snake River fall Chinook, UCR summer/fall Chinook, and Deschutes River summer/fall Chinook salmon produce subyearling smolts that migrate through and rear within the mainstem during summer, as do migrants from fall-run populations of LCR Chinook salmon. Hyde et al. (2004) focused on the sensitivity to changes in discharge in the 150 to 190 kcfs range, well beyond the effects anticipated under the RPA/PA and found that in the lower 35 miles of the Columbia River, such flow changes appear to have only slight impacts on the total area of shallow-water habitat available and the hours during which it would fit specific depth criteria. Due to extensive diking and the effects of tides, Jay et al. (2004) found that the amount of shallow-water habitat in the lower Columbia River varies very little over a much wider range of flow changes than those identified in the RPA/PA.

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[4] While insufficient data are available to clearly demonstrate a UWR Chinook survival response to changes in Willamette River flows, other Chinook ESUs and UWR steelhead have demonstrated reductions in survival with reductions in flow during their juvenile outmigration.

Thus, because the anticipated flow effects are well below 150 kcfs (maximum effect < 10 kcfs on a monthly average basis), we conclude that the effects on rearing habitats in the lower Columbia River and estuary would be negligible.

The reduction of the spring freshet associated with the RPA/PA would also influence habitat conditions in the Columbia River plume. Assuming that effects on the habitat value of the plume roughly equal the relative change in spring discharge, the RPA/PA would reduce the plume's habitat value by less than 2%. The plume's role as salmon and steelhead habitat is poorly understood. However, a 2% reduction in the size of the plume would appear to be a relatively small effect.

Groundfish

Two groundfish species, starry flounder and English sole, have EFH in areas affected by the RPA/PA. Starry flounder spawn in the ocean, and juveniles enter the estuary at a young age where they are associated with the bottom, feeding on amphipods and copepods (Fox et al. 1984). They are distributed throughout the estuary, but younger fish (less than 2 years) are more concentrated in the freshwater or low salinity areas. Fish older than 2 years are more concentrated in areas of higher salinity. During spring, abundance is generally low and flounder are restricted to part of Youngs Bay and an area between Tongue Point and Woody Island (approximately RM 29). During summer and fall, they are more widely distributed but are most abundant in areas of low velocity currents such as Grays Bay, Youngs Bay, Baker Bay, Cathlamet Bay, and intertidal habitats, where their principal prey, amphipods, concentrate.

The English sole is a marine species that is associated with the bottom for most of its life cycle. It prefers high salinities and therefore is found only in the downriver portions of the estuary where the population, primarily juveniles, feed and rear (Fox et al. 1984). English sole eat mainly copepods, amphipods, and mysids, but also incorporate the clam Macoma balthica, polychaetes, and oligochaetes into their diet. Sole less than 1 year old are localized in low-velocity, shallow areas such as the Ilwaco and Chinook Channels during spring, but are distributed further upriver in relatively saline water during summer and fall. Both their relative abundance and distribution in the estuary decrease in winter. Relatively few of the individuals in the estuary are 1 year old or older, and these are found downriver from the Astoria-Megler Bridge year round.

Both species are associated with low-velocity, shallow-water habitat in the estuary, where their prey species are abundant. Thus, effects on estuarine EFH for these species are likely to be similar to those described above for subyearling salmon. That is, the RPA/PA only slightly affects the total area of shallow-water rearing habitat available in the lower Columbia River and the hours during which it fits specific depth criteria, with the difference greatest during summer and in the upstream tidally-influenced reach closest to Bonneville Dam.

Coastal Pelagic Species

Northern anchovy are distributed from the Queen Charlotte Islands, British Columbia, to Magdalena Bay, Baja California, and anchovy have recently colonized the Gulf of California (PFMC 1998c). The population is divided into northern, central, and southern subpopulations, or stocks. The southern subpopulation is entirely within Mexican waters. The central subpopulation, which supports significant commercial fisheries in the U.S. and Mexico, ranges from approximately San Francisco, California, to Punta Baja, Baja California. The bulk of the central subpopulation is located in the Southern California Bight, a 20,000-square-nautical-mile area bounded by Point Conception, California, in the north and Point Descanso, Mexico (about 40 miles south of the U.S.-Mexico border) in the south. The geographic distribution of northern anchovy has been more consistent over time and is more nearshore than the geographic distribution of Pacific sardine.

The northern anchovy is commonly found both within the Columbia River estuary and offshore in large schools during all seasons. Adults spawn in the ocean, but all life stages can be found in the estuary where they feed mostly on copepods (and some phytoplankton) in the water column (Fox et al. 1984). Fish older than one year prefer higher salinity areas and are found further upriver when outflow is lower.

It is generally accepted that sardines off the west coast of North America form three subpopulations or stocks: a northern subpopulation (northern Baja California to Alaska), a southern subpopulation (off Baja California), and a Gulf of California subpopulation. A fourth, far northern subpopulation has also been postulated (PFMC 1998c). Although the ranges of the northern and southern subpopulations overlap, the stocks may move north and south at similar times and not overlap significantly.

Pacific sardines are pelagic at all life history stages. They occur in estuaries, but are most common in the nearshore and offshore domains along the coast. They have been captured in both purse and beach seines in the Columbia River estuary, often with anchovies. Like the northern anchovy, sardines are planktivorous, consuming both phytoplankton and zooplankton.

The RPA/PA has a small effect on flows in the Columbia River plume. For pelagic species, the increase in summer flows that would be provided by the RPA/PA means that the aerial extent of the low salinity environment in the plume would also be slightly enlarged. There is no information available on how habitat use by coastal pelagic species is affected by changes in flow on the order of the RPA/PA.

13.4.1.3 Water Quality Effects

The RPA/PA would have three primary effects on water quality: modified water temperatures, reduced turbidity (or increased clarity), and during spill operations, increased concentrations of dissolved gasses. These effects are strongest immediately downstream from the dams and diminishes in a downstream direction. Of these, water temperature is likely the most limiting water quality effect on Chinook and coho survival in the affected tributaries. However, total dissolved gas may have acute effects during spill operations. Because spill is an uncommon event at these projects, these adverse effects are uncommon.

Given that the influence of the Willamette Project on water quality diminishes with distance downstream from the dams and that total Willamette flows are a fraction of total Columbia River flows, the reduction of water quality related EFH quality exists only in the Willamette basin, primarily in the affected tributaries (e.g. North and South Santiams, McKenzie, and Middle Fork Willamette rivers) and affects only the EFH for Willamette basin Chinook and coho salmon. Both of these species would be adversely affected by the RPA/PA's effects on water quality.

13.5 Conclusion

NMFS concludes that the RPA/PA would adversely affect EFH for Columbia Basin Chinook and coho salmon by: continuing to block habitat for Willamette basin populations, degrading Willamette basin water quality, and modifying flows in the Willamette River and several of its salmon-bearing tributaries, and by contributing to diminished habitat quality in the lower Columbia River, its estuary and plume.

Effects on groundfish and coastal pelagic species EFH would be slight to negligible.

13.6 EFH Conservation Recommendations

Pursuant to §305(b)(4)(A) of the MSA, NMFS provides EFH conservation recommendations to the USACE, BPA, and Reclamation (the Action Agencies) to conserve EFH that would be adversely affected by the Willamette Project.

This MSA consultation and the EFH conservation recommendations are predicated on the assumption that the Action Agencies would adopt the RPA provided by NMFS in the Biological Opinion accompanying this MSA consultation. Failure by the Action Agencies to adopt any of the measures included in that RPA would render this MSA consultation null and void. Because lost access to historical spawning and rearing habitat upstream of Foster and Fall Creek dams is a primary adverse effect on designated EFH, NMFS recommends that the Action Agencies place high priority on achieving successful upstream and downstream fish passage at these dams. NMFS also recommends that the Action Agencies adopt and implement the terms and conditions in the Incidental Take Statement (ITS) in Chapter 11 of the Biological Opinion as EFH conservation measures. These terms and conditions in the ITS are necessary to minimize adverse impacts to EFH because they will address remaining project effects by minimizing harm to anadromous fish and EFH from construction and maintenance activities.

With improvements to passage, adherence to operating criteria described in the PA/RPA, and the adoption of the ITS measures, the RPA/PA's adverse effects on salmon EFH would be minimized.

13.7 Statutory Response Requirement

Pursuant to the MSA (§305(b)(4)(B)) and 50 CFR 600.920(j), Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations. In case of a response that is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations, including the scientific justification for any disagreements over the anticipated effects of the RPA/PA and the measures needed to avoid, minimize, mitigate, or offset such effects.

13.8 Reinitiation of Consultation

The Action Agencies must reinitiate EFH consultation with NMFS if the RPA/PA is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(k)).

Literature Cited

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Appendix A
Southern Resident Killer Whales

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SOUTHERN RESIDENT KILLER WHALES

A.1 Current Rangewide Status

The Southern Resident killer whale DPS consists of three pods, identified as J, K, and L pods. In this section, the status of the Southern Resident killer whales throughout their range is summarized. Although the entire Southern Resident DPS has potential to occur in the coastal waters at any time during the year, occurrence is more likely from November through April when Southern Residents are only occasionally found in the inland waters of Washington State. The information on the rangewide status of the species is generally representative of the status of the species in coastal waters. The final recovery plan for Southern Residents was issued in January 2008 (NMFS 2008Vg). This section summarizes information taken largely from the recovery plan, as well as new data that became available more recently. For more detailed information about this population, please refer to the Final Recovery Plan for Southern Resident Killer Whales, which can be found on the internet at www.nwr.noaa.gov.

A.1.1 Status & Trends

Although there is little information available regarding the historical abundance of Southern Resident killer whales, two methods have been used to estimate a historical population size of 140 to 200. The minimum estimate (~140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time of the captures. The maximum estimate (~200) is based on a recent genetic analysis of microsatellite DNA (NMFS 2003f).

At present, the Southern Resident population has declined to essentially the same size that was estimated during the early 1960s, when it was considered as likely depleted (Olesiuk et al. 1990) (Figure A.1-1). Since censuses began in 1974, J and K pods have steadily increased their sizes. However, the population suffered approximately a 20 percent decline from 1996-2001, largely driven by declines in L pod. There have been recent increases in the population from 2002-2006 indicating that L pod’s decline may have ended, however such a conclusion is premature. The 2007 census counted 87 Southern Resident killer whales, 25 in J pod, 19 in K pod and 43 in L pod.

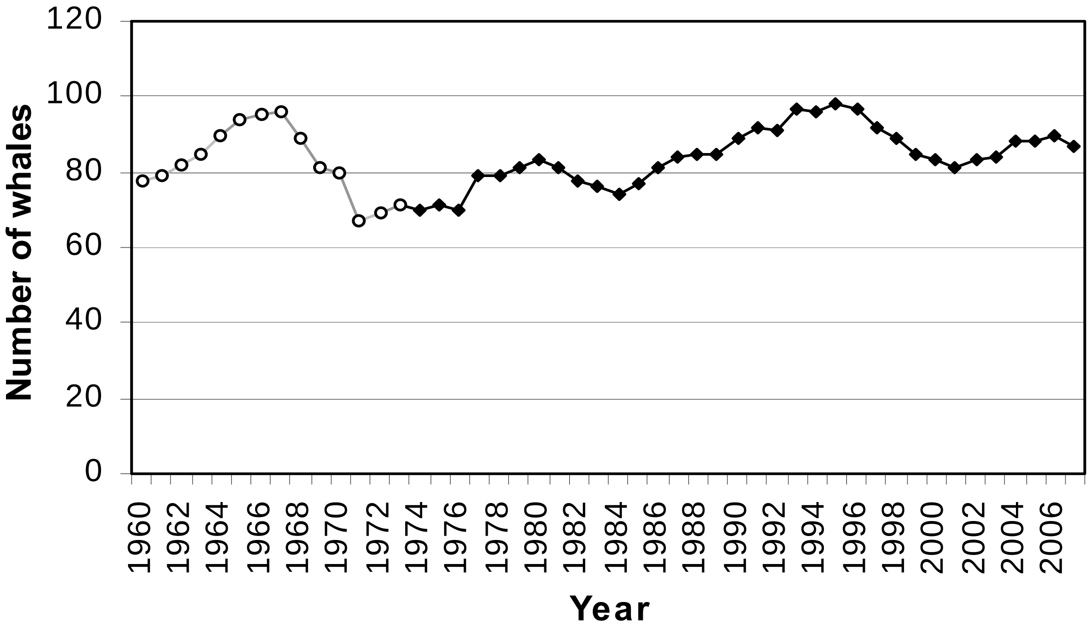

Figure A.1-1 Population size and trend of Southern Resident killer whales, 1960-2007. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2007 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpubl. data) and NMFS (2008g). Data for these years represent the number of whales present at the end of each calendar year except for 2007, when data extend only through October.

A.1.2 Listing Status

The Southern Resident killer whale Distinct Population Segment (DPS) was listed as endangered under the ESA on November 18, 2005 (NMFS 2005e). The final rule included information on the population decline in the 1990s and identified several potential factors that may have caused the decline or may be limiting recovery. These are: quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. Southern Residents are designated as “depleted” and “strategic” under the Marine Mammal Protection Act (MMPA) (NMFS 2003f). Critical habitat for the Southern Resident killer whale DPS was proposed on June 15, 2006 (NMFS 2006g) and the final designation of critical habitat was published November 29, 2006 (NMFS 2006d). Critical habitat includes approximately 2,560 square miles of inland waters in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Southern Resident critical habitat does not occur in the coastal waters, and is therefore not considered further in this consultation.

A.1.3 Range & Distribution

Southern Residents are found throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia (Figure A.1-2).

Figure A.1-2 Geographic Range (light shading) of the Southern Resident Killer Whale Population. Reprinted from Wiles (2004).

Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000). To date, there is no evidence that Southern Residents travel further than 50 km offshore (Ford et al. 2005). Although the entire Southern Resident DPS has potential to occur in coastal waters at any time during the year, occurrence is more likely during November to May.

Southern Residents spend the majority of their time from late spring to early autumn in inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) (Bigg 1982; Ford et al. 2000; Krahn et al. 2002) (Figure A.1-3). Typically, J, K and L pods arrive in May or June and spend most of their time in the core area of Georgia Basin and Puget Sound until departing in October. K and L pods also make frequent trips to the outer coasts of Washington and southern Vancouver Island during this time, which generally last a few days (Ford et al. 2000).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976				J,K								
1977												
1978			J,K									
1979											J,K	
1980												
1981				J,K								
1982						J,K				J,K		
1983										J,K	J,K	
1984						J,K						
1985						J,K						
1986					J,K							
1987										J,K	J,K	J,K
1988					J,K							
1989			J,K							J,K	J,K	J,K
1990												
1991					J,K					J,K		
1992												
1993					J,K							
1994										J,L		
1995												
1996										J,K	J,K	
1997										J,L	J,L	J,K
1998											J,K	
1999												
2000												
2001												
2002			J,K,L?									
2003												J,K
2004					J,L	J,L						J,K
2005		J?			J,L							
2006	J?											
2007	none					J,L						

Only J Pod present		Two pods present, as indicated		J, K, and L pods present		Data not available	

Figure A.1-3 Monthly occurrence of the three Southern Resident killer whale pods (J, K, and L) in the inland waters of Washington and British Columbia, 1976-2005. This geographic area is defined as the region east of Race Rocks at the southern end of Vancouver Island and Port Angeles on the Olympic Peninsula. Pods were recorded as present during a month if they were sighted on at least one day (Hanson 2008).

Late summer and early fall movements of Southern Residents in the Georgia Basin have remained fairly consistent since the early 1970s, with strong site fidelity shown to the region as a whole. However, presence in inland waters in the fall has increased in recent years (NMFS 2008g). It is uncertain whether potential variability in sighting effort over time has contributed to this trend. During early autumn, Southern Residents, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Osborne 1999). During late fall, winter, and early spring, the ranges and movements of the Southern Residents are less well known. Sightings through the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts of Vancouver Island and Washington (Krahn et al. 2002).

The Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000). However, recent sightings of members of K and L pods in Oregon (in 1999 and 2000) and California (in 2000, 2003, 2005, 2006 and 2008) have considerably extended the southern limit of their known range (NMFS 2008g). There have been 40 verified sightings or strandings of J, K or L pods along the outer coast from 1975 to present with most made from January to May. These include 16 records off Vancouver Island and the Queen Charlottes, 11 off Washington, four off Oregon, and nine off central California. Most records have occurred since 1996, but this is more likely because of increased viewing effort along the coast for this time of year. Sightings in Monterey Bay, California coincided with large runs of salmon, with feeding witnessed in 2000 (Black et al. 2001). L pod was also seen feeding on unidentified salmon off Westport, Washington, in March 2004 during the spring Chinook run in the Columbia River (M. B. Hanson, personal observation, as cited in Krahn et al. 2004).

A.1.4 Life History

Southern Resident killer whales are a long lived species, with late onset of sexual maturity (review in NMFS 2008g). Females produce a low number of surviving calves over the course of their reproductive life span (5.4 surviving calves over 25 years) (Olesiuk et al. 1990; Bain 1990). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990; Baird 2000; Ford et al. 2000). Groups of related matrilines form pods. Three pods – J, K, and L, make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of J clan.

Southern Resident killer whales are known to consume 22 species of fish and one species of squid (Scheffer and Slipp 1948; Ford et al. 1998, 2000; Ford and Ellis 2006; Saulitis et al. 2000). A long-term study of resident killer whale diet identified salmon as their preferred prey (96 percent of prey consumed during spring, summer and fall) (Ford and Ellis 2006). Feeding records for Southern and Northern Residents show a strong preference for Chinook salmon (72 percent of identified salmonids) during late spring to fall (Ford and Ellis 2006). Chum salmon (23 percent) are also taken in significant amounts, especially in autumn. Other salmon eaten include coho (2 percent), pink (3 percent) steelhead and sockeye (*O. mykiss, O. nerka* < 1 percent). The non-salmonids included Pacific herring, sablefish, Pacific halibut, and quillback and yelloweye rockfish. Chinook were preferred despite the much lower abundance of Chinook in the study area in comparison to other salmonids, probably because of the species' large size, high fat and energy content and year-round occurrence in the area. Killer whales also captured older (i.e., larger) than average Chinook (Ford and Ellis 2006).

Ongoing research continues to identify prey of Southern Residents through direct observation and scale sampling. More recently, researchers have started collecting fecal samples for analysis to address the potential biases of scale sampling. Although studies and analyses are not yet complete, preliminary results of ongoing sampling efforts are the best available information on diet composition of Southern Residents. When Southern Residents are generally concentrated in their "core summer area" (San Juan Islands) from May to September, their diet consists of approximately 86 percent Chinook salmon and 14 percent other salmon species (n=125 samples; Hanson et al. 2007, NWFSC unpubl. data). During all months combined their diet is approximately 69 percent Chinook and 31 percent other salmon species (n=160 samples). Sampling indicates an apparent shift to chum salmon in fall months when some Southern Residents are sighted inside Puget Sound (Hanson et al. 2007). Early results from genetic analysis of fecal and prey samples indicate that Southern Residents consume Fraser River origin Chinook, as well as salmon from Puget Sound, Washington and Oregon coasts, the Columbia River, and Central Valley California (Hanson et al. 2007). As further data are analyzed, they will provide information on which specific runs of salmon the whales are consuming in certain locations and seasons.

There are no fecal or prey samples or direct observations of predation events (where the prey was identified to species) when the whales are in coastal waters. Although less is known about diet preferences of Southern Residents off the Pacific Coast, it is likely that salmon are also important during late fall and winter when Southern Residents more predictably occur in coastal waters. Based on the best available information, Southern Residents may also prefer Chinook salmon when available in coastal waters. Chemical analyses also support the importance of salmon in the year-round diet of Southern Residents (Krahn et al. 2002, 2007). Krahn et al. (2002), examined the ratios of DDT (and its metabolites) to various PCB compounds in the whales, and concluded that the whales feed primarily on salmon throughout the year rather than other fish species. Krahn et al. (2007) analyzed stable isotopes from tissue samples collected in 1996 and 2004/2006. Carbon and nitrogen stable isotopes indicated that J and L pods consumed prey from similar trophic levels in 2004/2006 and showed no evidence of a large shift in the trophic level of prey consumed by L pod between 1996 and 2004/2006.

Researchers have estimated the energy requirements of killer whales and caloric values for salmon to calculate the number of fish needed per day. Salmon differ significantly in size across species and runs, and prey preference among salmon would affect annual consumption rates. Fewer salmon per day would be required from a larger preferred prey species such as Chinook salmon. NOAA Fisheries provides an estimate of the biological requirements of Southern Residents using the best available information on metabolic needs of the Southern Resident population and the caloric content of salmon (i.e., NMFS 2008h; NMFS 2008b).

A.2 Environmental Baseline

Because the entire listed entity is found in the coastal waters during some portion of the year, the status of the species in this area is the same as the range-wide status of the species, described above. The following discussion summarizes the conditions in coastal waters that are known to affect the likelihood that Southern Resident killer whales will survive and recover in the wild. The small size of the population increases the level of concern about any risks to Southern Resident killer whales (NMFS 2008g).

Natural Mortality

Seasonal mortality rates among Southern and Northern Resident whales are believed to be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer field research seasons. At least 12 newborn calves (9 in southern community and 3 in northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale eco-types in Washington and Oregon (Norman et al. 2004). Southern Resident strandings in coastal waters include three separate events (1995 and 1996 off of Northern Vancouver Island and the Queen Charlotte Islands, and 2002 offshore of Long Beach, Washington State), and the causes of death are unknown (NMFS 2008g).

In recent years, sighting reports indicate anecdotal evidence of thin killer whales returning to inland waters in the spring. For example, in March 2006 a thin female from the Southern Resident population (L54) with a nursing calf was sighted off Westport, WA. The sighting report indicated she had lost so much blubber that her ribs were showing under the skin (Cascadia Research 2008).

Prey Availability

Salmon, particularly Chinook salmon, are the preferred prey of Southern Resident killer whales in inland waters of Washington State during spring, summer and early fall. Chemical analyses support the importance of salmon in the year round diet of Southern Residents. Based on the best available information, Southern Residents may equally prefer Chinook salmon in inland and coastal waters. This analysis therefore focuses on effects of the proposed action and RPA on Chinook abundance in coastal waters. Focusing on Chinook provides a conservative estimate of potential effects of the proposed action and RPA on Southern Residents within coastal waters. The total abundance of all salmon and other potential prey species is difficult to quantify, but is orders of magnitude larger than the total abundance of Chinook in coastal waters.

When prey abundance is low, killer whales may spend more time and energy foraging than when prey abundance is high, with the potential for fitness consequences including reduced reproductive rates and higher mortality rates. Ford and Ellis (2006) correlated coastwide reduction in Chinook abundance (Alaska, British Columbia, and Washington) with decreased survival of resident whales (Northern and Southern Residents), but changes in killer whale abundance have not been linked to local areas or changes in salmon stock groups. No recent changes in salmon populations are obviously apparent that may be responsible for the recent decline in the Southern Resident population between 1996 and 2001 (NMFS 2008i). However, potential prey limitation is an area of ongoing research, and new information will be considered as it becomes available.

The availability of prey to Southern Resident killer whales is affected by a number of natural and human actions. Details regarding rangewide status of Chinook salmon in the Columbia River basin that are listed under the Endangered Species Act are described in Chapter 3 of this Opinion. NMFS expects the status of SR, UCR, LCR, and to some extent UWR- Chinook salmon to improve over the next ten years with implementation of the RPA described in the FCRPS Biological Opinion (NMFS 2008a). The baseline also includes Chinook ESUs that are not ESA-listed, notably the typically abundant Hanford Reach fall Chinook ESU and the Mid-Columbia spring Chinook ESU. Adult salmon are also affected by fisheries harvest in fresh and marine waters. In addition, climate effects from Pacific decadal oscillation and El Nino/Southern oscillation conditions and events cause changes in ocean productivity which can affect natural mortality of salmon, as described in more detail in Chapter 4 (4.1 General Basinwide Perspective). Predation in the ocean also contributes to natural mortality of salmon. Salmonids are prey for pelagic fishes, birds, and marine mammals.

The abundance of Chinook stocks across the coastal range of Southern Residents varies on an annual basis due to a combination of factors including ocean conditions and harvest management decisions (implementing the regulations for ocean salmon fisheries include ESA section 7 consultation, i.e., NMFS 2008b). For example, recent consultation on the Pacific Salmon Plan estimated there may be approximately 1.2 million adult Chinook salmon available in the coastal range of Southern Residents during the 2008-2009 regulatory cycle (NMFS 2008h). NOAA Fisheries found that PFMC salmon fisheries during the 2008-2009 regulatory cycle would cause a negligible reduction in prey resources with no detectible change in the ratio of prey availability to needs for Southern Residents within their coastal range (NMFS 2008h).This estimate includes estimated annual reductions in prey availability from fisheries harvest in coastal waters.

Contribution of Willamette River Chinook to ocean abundance in recent years is on the order of approximately 100,000 Chinook (NMFS 2008b), and recent returns to Willamette Falls range from approximately 20,000 to 96,000 Chinook (Kruzic 2008). Spring Chinook (hatchery and natural) returning to the Willamette River are younger than spring Chinook returns to the Willamette River prior to 1950 (Nicholas 1995). Currently, there is a higher percentage of age-4 fish, whereas historically there were more 5 year-old fish returning. Thus, UWR Chinook are less available to killer whales and smaller than historically, because older fish would stay in the ocean longer before returning to spawn and increase in size with increased age. However, a downward trend in size and age is generally applicable in many salmon populations (Quinn 2005). Size of individual salmon could affect the number of prey required by Southern Residents.

In general, the literature indicates a historical decrease in salmon age, size, or size at a given age. Hypotheses advanced to explain declining body size are density-dependent growth and selection of larger, older fish by selective fisheries. For example, Bigler et al. (1996) found a decreasing average body size in 45 of 47 salmon populations in the Northern Pacific. They also found that body size was inversely related to population abundance, and speculated that enhancement programs during the 1980s and 1990s increased population sizes, but reduced growth rates due to competition for food in the ocean. Recently, PFMC reported an increasing trend in coho and Chinook dressed weight (i.e., measured weight after the internal organs and blood are removed) over time, which could reflect increasing body size or size selectivity in the fisheries (PFMC 2006).

Fish size is influenced by factors such as environmental conditions, selectivity in fishing effort through gear type, fishing season or regulations, and hatchery practices. The available information on size is also confounded by factors including inter-population difference, when the size was recorded, and differing data sources and sampling methods (review in Quinn 2005). As a result, a comparative measure of prey biomass across the range of U.S. west coast salmon stocks for Southern Residents is not available and, for purposes of this Opinion, NOAA Fisheries relies on abundance estimates as a proxy measure (as in past consultation, i.e., NMFS 2006i).

Based on the best available information regarding diet composition for Southern Residents killer whales (which suggests that Chinook salmon are their preferred prey), their metabolic needs, and the caloric content of salmon, NOAA Fisheries estimates that the Southern Resident population (based on 2007 population size and structure) could need approximately 221,000 Chinook on an annual basis in coastal waters of their range (NMFS 2008b). Whether the whales' metabolic needs can be equally satisfied by hatchery fish versus wild fish depends on a comparison of the ocean distribution, run timing, and size of hatchery versus wild fish.

Southern Resident killer whales consume both natural and hatchery salmon (Barre 2008). Hatchery fish may differ from natural fish; however, the best available information indicates that the ocean distribution, run timing and size of hatchery and wild salmon does not follow a general pattern, but is case-specific with differences apparent in some populations but not others (NMFS 2008b). Therefore, the best available information does not indicate general differences in size, run-timing, or ocean distribution of hatchery and wild salmon for stocks available to Southern Residents across their range.

In the case of UWR Chinook, there is no known difference in the ocean distribution of hatchery and natural fish (PSC 2008). There are no significant differences between the present run-timing of hatchery and natural UWR Chinook (Schroder et al. 2006); however, there is a slight difference in size. On average, wild UWR Chinook return slightly longer than hatchery UWR Chinook (Firman et al. 2005), which translates to approximately 12.8% difference in the weight of individual hatchery and wild fish (Kruzic 2008).

Prey Quality

Contaminants enter fresh and marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Recent studies have documented high concentrations of PCBs, DDTs, and PBDEs in killer whales (Ross et al. 2000; Ylitalo et al. 2001; Reijnders and Aguilar 2002; Krahn et al. 2004). As top predators, when killer whales consume contaminated prey they accumulate the contaminants in their blubber. When prey is scarce, killer whales metabolize their blubber and the contaminants are mobilized (Krahn et al. 2002). Nursing females transmit large quantities of contaminants to their offspring. The mobilized contaminants can reduce the whales' resistance to disease and can affect reproduction.

Chinook salmon contain higher levels of some contaminants (i.e., PCBs) than other salmon species (O'Neill et al. 2005). Only limited information is available for contaminant levels of Chinook along the west coast (i.e., higher PCB and PBDE levels may distinguish Puget Sound-origin stocks, whereas higher DDT-signature may distinguish California origin stocks; Krahn et al. 2007). Adult Chinook that originate from the Willamette River basin may accumulate contaminants through development and growth in the freshwater and marine environment, and become a source of contaminants if consumed by Southern Residents.

Vessel Activities & Sound

Killer whales can be affected by the physical presence of vessels and by the sound the vessels generate. Several studies in the inland waters of Washington State and British Columbia have observed changes in killer whale behavior in the presence of vessels (Kruse 1991; Williams et al. 2002a, 2002b; Foote et al. 2004; Bain et al. 2006). These behavioral changes can affect the whales' foraging efficiency and the amount of energy they expend in migrating, foraging, and other activities. Sound from vessels can also interfere with communication and prey location. For a variety of reasons, vessel effects in coastal waters are likely small.

Commercial shipping, military vessels and recreational vessels occur in the coastal range of Southern Residents, but the area is vast in comparison to the numbers of vessels present. In addition, such vessels do not target whales, move at relatively slow speed and are likely detected and avoided by Southern Residents. Vessel sounds in coastal waters also likely have minor effects on killer whales. Most sound would be from large ships, tankers and tugs, and would be generate low frequency (5 to 500 Hz) (NRC 2003). While ships generate some broadband noise in the hearing range of whales, the majority of energy is below their peak hearing sensitivity.

Non-Vessel Sound

Anthropogenic (human-generated) sound in coastal waters within the range of Southern Residents is generated by sources besides vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication).

Sound from in-water construction activities could potentially occur through permits issued by the Army Corps of Engineers under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. Several consultations on federal projects in the coastal range of Southern Residents have been conducted and conservation measures have been included to minimize or eliminate potential effects to marine mammals. Sound, such as sonar generated by military vessels, also has the potential to disturb killer whales in coastal waters. As with vessel sounds, there are likely only minor effects on killer whales in the ocean from anthropogenic sounds because of the vastness of the area and low density of sound sources.

Oil Spills

Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. The coastal range of Southern Residents is primarily at risk from shipping accidents involving transiting oil tankers.

Southern Residents may also be affected by long-term repeated ingestion of sub-lethal quantities of petroleum hydrocarbons, although the effects are not well understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Wursig 1990; Geraci 1990). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Scientific Research

Most of the scientific research conducted on Southern Resident killer whales occurs in inland waters of Washington State and British Columbia. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. In 2006, NOAA Fisheries issued scientific research permits to seven investigators who intend to study Southern Resident killer whales. Research activities are typically conducted between May and October in inland waters. However, some permits include authorization to conduct research in coastal waters.

In the biological opinion NOAA Fisheries prepared to assess the impact of issuing the permits, we determined that the effects of these disturbances on Southern Residents were likely to adversely affect, but not jeopardize the continued existence of, the Southern Resident killer whales (NMFS 2006h). The annual authorized takes by harassment of Southern Residents under these permits totaled 1,935 non-invasive takes (e.g., surveys and photo-identification); 70 takes from biopsying, tagging, or breath sampling; and 820 takes due to unintentional harassment, although actual anticipated takes are substantially lower. While most of the authorized takes would occur in inland waters, a small portion of this disturbance is part of the baseline in the coastal range of Southern Residents.

Activities Outside U.S. Jurisdiction

The Southern Resident killer whales are highly migratory and may transit in and out of the waters of the United States and the high seas. NOAA Fisheries does not presently have information to assess the impact on Southern Residents of scientific research or boating activities within Canadian jurisdictional waters. NOAA Fisheries included information on Canadian fisheries within the coastal range of Southern Residents using the same methods to quantify U.S. fisheries in this area (NMFS 2008j).

Summary of the Environmental Baseline

Southern Resident killer whales are exposed to a wide variety of past and present state, federal and private actions in their coastal range as well as federal projects in this area that have already undergone formal section 7 consultation, and state or private actions that are contemporaneous with this consultation. All of the activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in coastal waters of their range.

Reductions in food availability, increased exposure to pollutants, and human disturbance have all been identified as potential threats to killer whales in Washington and British Columbia (Ford and Ellis 1999, 2005; Ford et al. 2000; Baird 2001; Krahn et al. 2002, 2004; Taylor 2004; Wiles 2004). Researchers are unsure about which threats are most significant to the Southern Resident population, and none of the threats have been identified as the cause of the recent decline of the Southern Resident killer whales (Krahn et al. 2002). There is limited information on how these factors or additional unknown factors may be affecting Southern Resident killer whales when in coastal waters in winter. It is possible that two or more of these factors may act together to harm the whales. The small size of the population increases the level of concern about all of these risks (NMFS 2008g).

A.3 Effects of the Reasonable & Prudent Alternative on Southern Resident Killer Whales

The RPA includes some aspects of the Proposed Action, and is referred to as the Proposed Action and RPA. We focus our effects analysis for Southern Resident killer whales on effects of the Proposed Action and RPA anticipated to be adopted by the Action Agencies. The potential effects of the Proposed Action and RPA on Southern Resident killer whales relate to prey availability. Chapters 2 and 9 describe the federal actions in the Proposed Action and RPA, respectively: the operation and configuration of the Willamette Project, maintenance of 42 miles of revetments, and related artificial propagation programs in the Willamette Basin as described in the 2000 Biological Assessment 2007 Supplemental Biological Assessment (USACE 2000, 2007a).

Most of the direct effects of the Proposed Action and RPA occur within the freshwater system of the Willamette Basin; effects experienced by Southern Residents in the coastal area are indirect. That is, the Proposed Action and RPA may affect the abundance of killer whale prey in the ocean. Changes in prey abundance would affect the entire DPS of Southern Resident killer whales. The best available information indicates that salmon are the preferred prey of killer whales year round (Krahn et al. 2002, 2007), including in coastal waters, and that Chinook are the preferred salmon species (Ford and Ellis 2006). Prey abundance is a concern for killer whales both in the near and long term. To survive in the near term, killer whales require regular supplies of adult Chinook prey in the ocean, and to recover over the longer term, killer whales require abundant Chinook stocks coast-wide, likely including stocks from the Willamette River (Status of the Species). This analysis considers the short-term and long-term effects of the Proposed Action and RPA.

A.3.1 Short-term Effects on Southern Resident Killer Whales

The Proposed Action and RPA combined include the operation and configuration of the Willamette Project including substantive measures for fish passage, water quality, flow management, and water contracting, maintenance of 42 miles of revetments, and operation of the hatchery mitigation programs. Hatchery measures include continued funding of hatchery programs and improvements to program management and facilities for hatcheries in the Willamette Basin. The RPA sets implementation schedules for each action over the 15 year time frame of the Opinion (Table 9.10-1). NMFS has quantified short-term effects of hatchery production and project operations on Chinook prey available to Southern Residents.

Effects of Artificial Production

The Proposed Action and RPA include continued funding for artificial propagation of Chinook salmon, which produces killer whale prey. Therefore, this analysis uses the current levels of funding and production which will continue over the short term. Action Agency (BPA, Corps, and Reclamation) funding accounts for approximately 79 percent of the Chinook smolts released in the upper Willamette basin as mitigation for loss of habitat above the Corps dams as well as ongoing operations and maintenance (Simmons 2008). In recent years, hatchery returns to Willamette Falls represented approximately 90 percent of the total Chinook run (ODFW 2008c). If approximately 90 percent of the Chinook returns to Willamette Falls are hatchery produced, and if the Proposed Action and RPA produce approximately 79 percent of all returning hatchery Chinook, then approximately 71 percent of the total annual return of Chinook above Willamette Falls can be attributed to the Proposed Action and RPA.

Effects of Project Operations for Flood Control, Hydropower, Water Supply & Maintenance of Revetments

In addition to production via hatchery mitigation programs, project operations cause mortality of adult and juvenile Chinook, which when considered alone would reduce the number of adult Chinook in the ocean and reduce prey availability. To determine whether the Chinook prey base for killer whales is adversely affected by the Proposed Action and RPA, we compare the decrease in the prey base for killer whales resulting from project-caused mortality to the increase in the prey base resulting from the hatchery programs funded by the action agencies.

The effect of the hatchery programs is to produce 71 percent of the UWR Chinook available to the killer whales. In order for decreases caused by the Willamette Project to exceed this production, the project would have to cause a greater reduction in the total number of UWR Chinook available to killer whales. For the reasons discussed below, it is unlikely that mortality from the Willamette Project results in a net reduction in the killer whale prey base. In this analysis, NMFS compares the percent of adult Chinook produced from hatchery actions to the percent reduction of naturally produced Chinook.

Naturally produced Chinook salmon in the upper Willamette system are perpetuated by returning adults that spawn below Project dams, or are transported above Project dams. Project operations cause high levels of mortality of spawners or their progeny both below the dams and as a result of transport. By releasing flows with elevated water temperatures during fall reservoir evacuation, operations contribute to high levels of mortality to adult Chinook before they spawn and to incubating eggs in the downstream reaches. Additionally, adult Chinook transported above the dams experience some mortality from trapping and handling, and the progeny of those that do spawn experience high mortality during outmigration through the reservoirs and past the concrete. Currently, approximately 61 percent of Chinook returning to Willamette Falls that would have naturally spawned are not contributing progeny (Kruzic 2008). A conservative assumption for relatively healthy systems is that spawner-to-spawner rates are on the order of one-to-one. Given this assumption, project operations reduce naturally produced Chinook in subsequent years by as much as 61 percent.

The 61 percent reduction includes wild and hatchery-origin fish, many of which are produced as part of the action. To assess the effects of the action, NOAA Fisheries considers the net production of hatchery-origin fish that survive and naturally-produce as adults and the net loss of wild fish that do not survive to replace themselves. Recall that 90 percent of the Chinook returns to Willamette Falls are hatchery produced, and the remaining 10 percent are wild. Assuming that wild and hatchery fish are equally susceptible to the effects of project operations, the net gain in the abundance of fish in the next generation as a result of the action agency's hatchery production is 16 percent (0.71 hatchery production-(0.90 returning hatchery fish*0.61 mortality)), and the net loss in the abundance of fish in the next generation as a result of the mortalities of wild fish is 6 percent (0.61 mortality*0.10 returning wild fish). Although the wild fish are slightly larger than hatchery fish, the net gain in the total number of hatchery adults is almost three times the loss of wild adults.

Therefore, the hatchery production contained in the Proposed Action and RPA more than offsets losses to the killer whale prey base. As the Proposed Action and RPA are implemented, the survival and numbers of natural-origin Chinook are expected to increase, which may increase the prey base and biomass of prey for killer whales as discussed below in long-term effects.

A.3.2 Long-term Effects on Southern Resident Killer Whales

The analysis of effects of the Proposed Action and RPA on UWR Chinook salmon – prey of Southern Resident killer whales -- concludes that the species is expected to survive with an adequate potential for recovery. Additionally, the Proposed Action and RPA will not adversely modify the designated critical habitat of the ESU. These conclusions were derived by reviewing the effects of the Proposed Action and RPA, the effects of the environmental baseline, and any cumulative effects. To this end, NMFS anticipates that the Proposed Action and RPA measures will substantially improve the status of the UWR Chinook ESU (Chapters 2 and 9). Many of the RPA measures will specifically address lack of passage and degraded remaining habitat, which are the key limiting factors for natural production of UWR Chinook. Although all RPA measures will be implemented over the 15-year term of the consultation, significant improvements in the ESU status will accrue over the next 30 years.

The Proposed Action and the RPA include continued funding of hatchery programs and improvements to program management and facilities for hatcheries in the Willamette Basin. The potential harmful effects of continued artificial production on long-term fitness of salmon populations are discussed in Chapter 5, Effects of the Proposed Action (Section 5.1.5). Specifically, hatcheries can negatively affect population viability by reducing abundance, productivity, spatial distribution and/or diversity of natural-origin fish (described in McElhany et al. 2000).

As discussed further in Section 9.6, hatchery RPA actions are necessary to reduce short- and long-term risks and to increase the long-term viability of the UWR Chinook ESU. These measures include implementation of the actions described in the Hatchery and Genetic Management Plan for spring Chinook, which describes detailed management practices for each hatchery. Additional actions include improvements of hatchery facilities basin-wide (including those associated with broodstock collection and outplanting), continued mass-marking of hatchery-produced juveniles, a new sorting facility at Leaburg Dam on the McKenzie River, and after the sorting facility is built, limiting hatchery-origin Chinook to areas downstream of Cougar Dam on the South Fork McKenzie. Levels of hatchery production could be reduced once natural production increases. For example, the existing hatchery programs are being used to reintroduce Chinook back into historical habitat to restore natural production above Project dams. Once natural returns rebuild in the areas above the dams the proportion of artificially produced salmon in the Willamette Basin would decrease. Some hatchery production will likely be continued indefinitely to mitigate for the loss of Chinook habitat inundated by reservoirs, but long term hatchery mitigation will be consistent with the management goals to conserve and recover natural fish (Section 5.1.5 and Figure 5.1-1).

As discussed previously, hatchery UWR Chinook currently weigh slightly less than wild UWR Chinook (Environmental Baseline Section). Provided actions of the Proposed Action and RPA are anticipated to increase natural production in the long term, there could be an increase in biomass available to Southern Residents as the proportion of wild UWR Chinook increases.

Over the long term, the abundance of UWR Chinook, and thus of Southern Resident killer whale prey, may be affected by climate change. The Proposed Action and measure #1 in the RPA describe a coordination mechanism that will enable the Action Agencies to synthesize, update, and modify implementation to respond to new information, including the effects of climate change on listed salmonids. This will ensure conditions needed for adequate production of listed salmonids from the Upper Willamette Basin.

A.4 Cumulative Effects

Cumulative effects are those effects of future tribal, state, local or private activities, not involving Federal activities, reasonably certain to occur within the action area (50 CFR 402.02). For the purpose of the Southern Resident killer whale analysis, this area is the coastal range of the species. Future Federal actions will be reviewed through separate section 7 consultation processes.

Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities are primarily those conducted under state, tribal or federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative. A Final Recovery Plan for Southern Resident Killer Whales was published January 24, 2008 (NMFS 2008k). Although state, tribal and local governments have developed plans and initiatives to benefit marine fish species, ESA listed salmon, and the listed Southern Residents, they must be applied and sustained in a comprehensive way before NOAA Fisheries can consider them “reasonably certain to occur” in its analysis of cumulative effects. Details regarding cumulative effects for Chinook salmon in the Willamette Basin are described in Chapter 6 for the ESUs affected.

Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in Chapter 6 whether future non-Federal actions will lead to an increase or decrease in prey available to Southern Resident killer whales, or have other effects on their survival and recovery.

A.5 Conclusion

The Willamette Project operations cause high levels of mortality to returning UWR Chinook and the progeny of spawners, which in turn results in fewer adult Chinook in the ocean and reduced prey availability for Southern Resident killer whales. At the same time, hatchery production contained in the proposed action and RPA increases the adult Chinook salmon available to Southern Resident killer whales as prey. Hatchery production more than offsets project mortality with the net result that killer whale prey base is not reduced, and the Southern Resident killer whales are not likely to be adversely affected by the proposed action and RPA. Longer term, the proposed action and RPA will reduce the potential negative effects of hatchery production and support the survival and recovery of listed salmonids. The long term improvement of UWR Chinook is a benefit to Southern Resident killer whales in the long term. Therefore, NOAA Fisheries concurs with the Action Agency determination that the proposed action and RPA may affect, but are not likely to adversely affect Southern Resident killer whales for purposes of an informal ESA consultation, 50 C.F.R. § 402.14(a). If additional information on Southern Resident killer whales becomes available, then this determination may be reconsidered pursuant to 50 C.F.R. § 402.16.

Appendix B
Southern DPS of North American Green Sturgeon

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SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

Purpose

This Chapter provides discusses the status of the Southern DPS of North American green sturgeon (*Acipenser medirostris*) and the effects of the Proposed Action and RPA on the species. Much of this information was provided by the Action Agencies in USACE et al. (2008b) and in USACE (2008c).

B.1 Status of the Species

B.1.1 Listing

Upon completion of a status review, NOAA Fisheries determined that green sturgeon comprise two DPSs that qualify as species under ESA: 1) a northern DPS, consisting of populations in coastal systems from the Eel River, California northward, that was determined to not warrant listing; and 2) a southern DPS consisting of coastal and Central Valley populations south of the Eel River, with the only known spawning population in the Sacramento River (Adams et al. 2002). NMFS listed the southern distinct population segment (DPS) of green sturgeon as threatened under the ESA on April 7, 2006 (NMFS 2006c). Take prohibitions via section 4(d) of the ESA have not yet been promulgated, nor has critical habitat yet been designated for the southern DPS of green sturgeon, although both actions are expected to occur later in 2008.

B.1.2 Life History

Green sturgeon are the most marine-oriented of the North American sturgeon species. Juveniles of this species are able to enter estuarine waters after only one year in freshwater. During this time, they are believed to feed on benthic invertebrates, although little is known about rearing habitats and feeding requirements. Green sturgeon are known to range in nearshore marine waters from Mexico to the Bering Sea, and are commonly observed in bays and estuaries along the west coast of North America, including the Columbia River (NMFS 2008l). McLain (2006) noted that Southern DPS green sturgeon were first determined to occur in Oregon and Washington waters in the late 1950s when individuals tagged San Pablo Bay were recovered in the Columbia River estuary. The proportion of the Southern relative to Northern DPS is high (~67-82%; 121 of 155 fish sampled) (Israel and May 2007). Aggregations of adults occupy deeper water within the lower Columbia River and estuary, up to the Bonneville Dam, primarily during summer months (WDFW and ODFW 2002, Moser and Lindley 2007). Beamis and Kynard (1997) suggested that green sturgeon move into estuaries of non-natal rivers to feed.

Information from fisheries-dependent sampling suggests that green sturgeon only occupy large estuaries during the summer and early fall in the northwestern United States. Green sturgeon are known to enter Washington estuaries during summer (Moser and Lindley 2007). There is no evidence of spawning in the lower Columbia and little information on the type(s) of habitat occupied during the period of residence. Green sturgeon in the lower Columbia River, including those that are known to be part of the Southern DPS, are most likely feeding, but, to date, all stomachs examined (n>50) have been empty (Grimaldo and Zeug 2001). Wydoski and Whitney (1979), reported that green sturgeon in the Columbia River estuary were known to feed on anchovies and clams. Although the DPS affiliation of these fish is unknown, it is likely that the two groups have similar feeding habitats.

B.1.3 Status/Population Trend

Quality data on current population sizes and trends for green sturgeon is non-existent. Lacking any empirical abundance information, Beamesderfer et al. (2007) recently attempted to characterize the relative size of the Sacramento-San Joaquin green sturgeon population (Southern DPS) by comparison with the Klamath River population (Northern DPS). Using harvest rate data for the Klamath River tribal fishery and assuming adults represent 10% of the population at equilibrium, they roughly estimate the Klamath population at 19,000 fish with an annual recruitment of 1,800 age-1 fish. Given the relative abundance of the two stocks in the Columbia River estuary based on genetic samples, they speculate that the abundance of the Sacramento population may equal or exceed the Klamath population estimate. Beamesderfer et al. (2007) estimate that collective abundance of the various green sturgeon populations may be larger than previously thought due to seasonal high abundances in the Columbia River, Willapa Bay, and Grays River estuaries and other coastal tributaries, historical high harvest in different areas at different times, and the assumption that a significant portion of each population remains in the ocean at any given time.

B.1.4 Key Limiting Factors for Green Sturgeon

The principal factor in the decline of the Southern DPS is the reduction of the spawning habitat to a limited section of the Sacramento River (NMFS 2006c). The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon's extirpation. Insufficient freshwater flow rates in spawning areas, contaminants (e.g., pesticides), bycatch of green sturgeon in fisheries, potential poaching (e.g., for caviar), entrainment of juveniles by water projects, influence of exotic species, small population size, impassable migration barriers, and elevated water temperatures in the spawning and rearing habitat also pose threats to this species (NMFS 2006c).

B.1.5 Harvest Effects

In the past, take of green sturgeon may have occurred from direct harvest in sport and commercial fisheries and from catch and release mortality in commercial fisheries. In the more recent years, the take of green sturgeon in the Columbia River was incidental to fisheries directed at white sturgeon. The numerous management actions implemented by the states of Oregon and Washington since 1994 to control white sturgeon harvest also reduced harvest of green sturgeon, including a reduction of impacts to the listed Southern DPS. The reduced catch of green sturgeon in recent years is believed to be the result of these collective management actions by the states resulting in lower catch, and is not considered indicative of lower abundance of the stock (TAC 2008).

Incidental take of green sturgeon primarily occurs during the early-fall (August) and late-fall (September-November) seasons, concurrent with peak abundance of white sturgeon in the lower Columbia River. Sturgeon angler effort and catch in the estuary increased steadily during the 1990s and peaked in 1998 when anglers made 86,400 trips and caught 30,300 white sturgeon, or 73% of the total catch below Bonneville Dam (TAC 2008). Since 1989, all fisheries affecting lower Columbia River white sturgeon have been managed for Optimum Sustainable Yield (OSY) to provide sustainable broodstock recruitment and ensure the overall health of the white sturgeon population. Beginning in 1996, the states formally adopted a three-year Joint State management agreement based on OSY to guide Columbia River sturgeon fisheries and management decisions. Although the majority of the tenets within the current Joint State sturgeon management agreement focus on white sturgeon, a few objectives specific to benefit green sturgeon management were also included. Beginning July 7, 2006, and in response to the ESA listing of the Southern DPS, retention of green sturgeon in the commercial fisheries was disallowed (TAC 2008). Beginning in January 2007, the states changed the regulations in the recreational fishery to also disallow retention of green sturgeon (TAC 2008). The delay in the implementation of non-retention requirements in the recreational fishery were related to the prescribed process for changing sport regulations and the need for a concurrent public education process.

Harvest of green sturgeon has declined from an average of 1,388 fish annually during 1991-2000 to 154 fish per year since 2001 due to these changes in regulations and season structure (Table B.1-1). During 1996-2006, an average of 61 green sturgeon were harvested in the recreational fishery (Table B.1-1). During 1996-2006, anglers released an average of seven green sturgeon each year (2.7 sub legal-, 3.1 legal-, and 1.3 over legal-sized) (TAC 2008).

Table B.1-1 Lower Columbia River Green Sturgeon Catch, 1991-2007 (TAC 2008).

Green Sturgeon						
Year	Sport	Commercial				
		Winter	Summer	Early Fall	Late Fall	Total
1991	22	4	--	2	3,180	3,208
1992	73	10	--	1,750	400	2,233
1993	15	1	--	--	2,220	2,236
1994	132	1	--	--	240	373
1995	21	--	--	--	390	411
1996	63	1	--	--	610	674
1997	41	2	--	1,474	138	1,655
1998	73	0	--	743	151	967
1999	93	2	--	508	279	882
2000	32	0	--	568	636	1,236
2001	50	4	--	338	--	392
2002	51	7	--	--	156	214
2003	52	1	--	11	27	91

Green Sturgeon						
Year	**Sport**	**Commercial**				
		Winter	**Summer**	**Early Fall**	**Late Fall**	**Total**
2004	29	1	--	6	51	87
2005	119	0	38	32	21	210
2006	70	16	0	--	--	86
2007						0

B.1.6 Other Effects in the Environmental Baseline

In addition to these harvest effects on green sturgeon, the general discussion of the environmental baseline in the estuary in Section 4.11, and in the further discussions in Section 5.11, also apply and inform these decisions.

B.2 Effects of the Proposed Action & RPA

B.2.1 Effects of Artificial Propagation

Green sturgeon are principally bottom (benthic) feeders and are not known to rely on salmonids as prey. Thus, artificial propagation of UWR Chinook or of summer steelhead is not likely to affect this species.

B.2.2 Effects of Project Operations for Flood Control, Hydropower, and Water Supply

- Green sturgeon only encounter the effects of the Willamette Project between the confluence of the Willamette River and the Columbia River plume, including the Columbia River estuary.

- Adults have been found in this portion of the action area only during late summer and fall. At this time, operation of the Willamette Project has a small effect on streamflow in the lower Columbia (i.e., flows are increased about 2.9 kcfs (<2%) in August and 5.4 kcfs (5.4%) in September). Such very small flow reductions are likely to have slight to negligible effects on the deeper water habitat used by green sturgeon or on the fish themselves.

- Green sturgeon are bottom (benthic) feeders and are not known to rely on salmonids as prey.

B.2.3 Effects of Maintaining Revetments

The USACE has entered into agreements to maintain about 42 miles of revetments along the mainstem Willamette River and its tributaries (USACE 2000). These structures limit natural channel migration and the formation of complex and diverse habitats, limiting salmonid productivity. Because green sturgeon are principally bottom (benthic) feeders and are not known to rely on salmonids as prey maintaining revetments in the mainstem Willamette and its tributaries is not likely to affect this species.

B.3 Conclusion

By changing flow in the Columbia River estuary, the proposed action may affect the Southern DPS of North American green sturgeon. However, effects on the species are likely to be slight to negligible. Adults, the only life stage known to occupy the lower Columbia River, prefer deep water habitats that are generally unaffected by flow changes of this magnitude (very small). NMFS therefore concludes that proposed action and RPA may affect, but is not likely to adversely affect the Southern DPS of North American green sturgeon. If additional information on this DPS becomes available, then this determination may be reconsidered.

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Appendix C
Willamette Project Rule Curves, revised 2007

U.S. Army Corps of Engineers

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Rule Curves for All Willamette Projects received 1/15/2008, email from Mary-Karen Scullion, USACE to John K Johnson, NMFS

STORAGE (IN KAF)

	HCR	LOP	FAL	COT	DOR	FRN	CGR	BLU	GPR	FOS	DET
1-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
2-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
3-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
4-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
5-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
6-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
7-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
8-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
9-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
10-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
11-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
12-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
13-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
14-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
15-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
16-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
17-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
18-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
19-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
20-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
21-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
22-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
23-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
24-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
25-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
26-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
27-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
28-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
29-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
30-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
31-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383
1-Feb	158.693	123.973	9.621	3.139	7.094	4.078	54.210	3.970	164.177	31.317	159.009
2-Feb	162.013	129.185	11.354	3.407	7.695	5.356	56.220	5.158	168.495	31.568	163.635
3-Feb	165.333	134.396	13.088	3.674	8.297	6.633	58.230	6.346	172.813	31.819	168.261
4-Feb	168.653	139.607	14.821	3.942	8.898	7.910	60.240	7.534	177.131	32.070	172.887
5-Feb	171.973	144.819	16.554	4.210	9.500	9.187	62.250	8.722	181.449	32.321	177.513
6-Feb	175.293	150.030	18.287	4.478	10.101	10.465	64.260	9.910	185.767	32.572	182.139
7-Feb	178.613	155.242	20.021	4.745	10.703	11.742	66.270	11.098	190.085	32.823	186.765
8-Feb	181.933	160.453	21.754	5.013	11.304	13.019	68.280	12.286	194.402	33.074	191.391
9-Feb	185.253	165.664	23.487	5.281	11.906	14.297	70.290	13.474	198.720	33.325	196.017
10-Feb	188.573	170.876	25.221	5.548	12.507	15.574	72.300	14.662	203.038	33.576	200.643
11-Feb	191.893	176.087	26.954	5.816	13.109	16.851	74.310	15.850	207.356	33.827	205.269
12-Feb	195.213	181.298	28.687	6.084	13.710	18.128	76.320	17.038	211.674	34.078	209.895
13-Feb	198.533	186.510	30.421	6.351	14.312	19.406	78.330	18.226	215.992	34.329	214.521
14-Feb	201.854	191.721	32.154	6.619	14.913	20.683	80.340	19.414	220.310	34.580	219.147
15-Feb	205.174	196.932	33.887	6.887	15.515	21.960	82.350	20.602	224.628	34.831	223.772
16-Feb	208.494	202.144	35.620	7.155	16.116	23.238	84.360	21.790	228.946	35.082	228.398
17-Feb	211.814	207.355	37.354	7.422	16.718	24.515	86.370	22.978	233.264	35.333	233.024
18-Feb	215.134	212.566	39.087	7.690	17.319	25.792	88.380	24.166	237.582	35.584	237.650
19-Feb	218.454	217.778	40.820	7.958	17.921	27.069	90.390	25.354	241.900	35.835	242.276
20-Feb	221.774	222.989	42.554	8.225	18.522	28.347	92.400	26.542	246.218	36.086	246.902
21-Feb	225.094	228.201	44.287	8.493	19.124	29.624	94.410	27.730	250.536	36.337	251.528
22-Feb	228.414	233.412	46.020	8.761	19.725	30.901	96.420	28.918	254.853	36.588	256.154
23-Feb	231.734	238.623	47.754	9.028	20.327	32.179	98.430	30.106	259.171	36.839	260.780
24-Feb	235.054	243.835	49.487	9.296	20.928	33.456	100.440	31.294	263.489	37.090	265.406
25-Feb	238.374	249.046	51.220	9.564	21.530	34.733	102.450	32.482	267.807	37.341	270.032
26-Feb	241.694	254.257	52.953	9.832	22.131	36.010	104.460	33.670	272.125	37.592	274.658
27-Feb	245.014	259.469	54.687	10.099	22.733	37.288	106.470	34.858	276.443	37.843	279.284
28-Feb	248.334	264.680	56.420	10.367	23.334	38.565	108.480	36.046	280.761	38.094	283.910
1-Mar	249.690	267.191	58.154	10.635	23.935	39.842	109.614	37.234	282.579	38.345	286.215

ELEVATION (IN FEET)

	HCR	LOP	FAL	COT	DOR	FRN	CGR	BLU	GPR	FOS	DET
1-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
2-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
3-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
4-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
5-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
6-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
7-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
8-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
9-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
10-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
11-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
12-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
13-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
14-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
15-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
16-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
17-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
18-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
19-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
20-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
21-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
22-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
23-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
24-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
25-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
26-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
27-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
28-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
29-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
30-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
31-Jan	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
1-Feb	1450.1	827.5	728.0	750.0	770.5	354.1	1535.5	1180.0	924.1	613.3	1452.7
2-Feb	1452.2	829.9	731.5	750.9	771.6	355.1	1538.8	1188.4	926.1	613.6	1455.3
3-Feb	1454.2	832.2	734.7	751.7	772.8	355.9	1542.1	1196.0	928.1	613.8	1457.8
4-Feb	1456.2	834.5	737.6	752.5	773.9	356.6	1545.4	1202.8	930.1	614.1	1460.4
5-Feb	1458.2	836.8	740.4	753.3	774.9	357.2	1548.6	1209.1	932.0	614.4	1462.9
6-Feb	1460.2	839.0	743.1	754.0	776.0	357.8	1551.8	1214.9	933.9	614.7	1465.3
7-Feb	1462.2	841.1	745.8	754.7	777.0	358.3	1554.9	1220.3	935.8	614.9	1467.7
8-Feb	1464.1	843.3	748.5	755.4	778.0	358.8	1558.0	1225.3	937.7	615.2	1470.1
9-Feb	1466.0	845.3	751.2	756.0	779.0	359.3	1561.1	1230.0	939.5	615.5	1472.5
10-Feb	1467.9	847.4	753.7	756.6	780.0	359.7	1564.1	1234.6	941.3	615.8	1474.9
11-Feb	1469.8	849.4	756.2	757.2	780.9	360.1	1567.1	1238.8	943.1	616.0	1477.2
12-Feb	1471.6	851.3	758.5	757.8	781.9	360.5	1570.0	1242.9	944.9	616.3	1479.5
13-Feb	1473.4	853.3	760.8	758.4	782.8	360.9	1572.9	1246.8	946.6	616.6	1481.8
14-Feb	1475.2	855.2	763.0	758.9	783.7	361.2	1575.8	1250.5	948.3	616.8	1484.0
15-Feb	1477.0	857.0	765.1	759.5	784.5	361.6	1578.6	1254.0	950.0	617.1	1486.2
16-Feb	1478.7	858.8	767.2	760.0	785.4	361.9	1581.4	1257.3	951.7	617.4	1488.3
17-Feb	1480.4	860.6	769.3	760.5	786.2	362.2	1584.1	1260.6	953.4	617.6	1490.5
18-Feb	1482.1	862.4	771.2	761.0	787.0	362.6	1586.9	1263.6	955.0	617.9	1492.6
19-Feb	1483.8	864.2	773.1	761.5	787.8	362.9	1589.6	1266.6	956.6	618.2	1494.6
20-Feb	1485.5	865.9	775.0	762.0	788.6	363.2	1592.2	1269.4	958.2	618.4	1496.7
21-Feb	1487.2	867.6	776.7	762.5	789.4	363.5	1594.9	1272.0	959.8	618.7	1498.7
22-Feb	1488.8	869.3	778.4	762.9	790.2	363.7	1597.5	1274.6	961.4	619.0	1500.7
23-Feb	1490.4	871.0	780.1	763.4	790.9	364.0	1600.1	1277.1	962.9	619.2	1502.6
24-Feb	1492.1	872.6	781.7	763.9	791.7	364.3	1602.6	1279.5	964.4	619.5	1504.6
25-Feb	1493.7	874.3	783.3	764.3	792.4	364.5	1605.2	1281.8	965.9	619.8	1506.5
26-Feb	1495.2	875.9	784.8	764.8	793.1	364.8	1607.7	1284.1	967.4	620.0	1508.4
27-Feb	1496.8	877.5	786.4	765.2	793.8	365.1	1610.1	1286.3	968.9	620.3	1510.2
28-Feb	1498.4	879.0	788.0	765.6	794.5	365.3	1612.6	1288.4	970.4	620.5	1512.1
1-Mar	1499.0	879.8	789.5	766.1	795.2	365.6	1613.9	1290.5	971.0	620.8	1513.0

2-Mar	251.045	269.703	58.994	10.902	24.537	41.120	110.748	37.876	284.397	38.596	288.519
3-Mar	252.401	272.214	59.835	11.170	25.138	42.397	111.882	38.518	286.215	38.847	290.824
4-Mar	253.757	274.725	60.675	11.438	25.740	43.674	113.016	39.160	288.033	39.098	293.128
5-Mar	255.113	277.237	61.516	11.706	26.341	44.951	114.150	39.802	289.851	39.349	295.433
6-Mar	256.468	279.748	62.356	11.973	26.943	46.229	115.285	40.444	291.669	39.600	297.737
7-Mar	257.824	282.259	63.197	12.241	27.544	47.506	116.419	41.086	293.487	39.851	300.042
8-Mar	259.180	284.771	64.037	12.509	28.146	48.783	117.553	41.728	295.304	40.102	302.346
9-Mar	260.536	287.282	64.877	12.777	28.747	50.060	118.687	42.370	297.122	40.353	304.651
10-Mar	261.891	289.793	65.718	13.044	29.349	51.338	119.821	43.012	298.940	40.604	306.955
11-Mar	263.247	292.305	66.558	13.312	29.950	52.615	120.955	43.654	300.758	40.855	309.260
12-Mar	264.603	294.816	67.399	13.580	30.552	53.892	122.089	44.296	302.576	41.106	311.564
13-Mar	265.959	297.327	68.239	13.848	31.153	55.169	123.223	44.938	304.394	41.357	313.869
14-Mar	267.314	299.839	69.080	14.115	31.755	56.447	124.357	45.580	306.212	41.608	316.173
15-Mar	268.670	302.350	69.920	14.383	32.356	57.724	125.491	46.222	308.030	41.859	318.478
16-Mar	270.026	304.861	70.760	14.651	32.958	59.001	126.625	46.864	309.848	42.110	320.783
17-Mar	271.382	307.373	71.601	14.918	33.559	60.279	127.759	47.506	311.666	42.361	323.087
18-Mar	272.737	309.884	72.441	15.186	34.161	61.556	128.894	48.148	313.484	42.612	325.392
19-Mar	274.093	312.396	73.282	15.454	34.762	62.833	130.028	48.790	315.302	42.863	327.696
20-Mar	275.449	314.907	74.122	15.721	35.364	64.111	131.162	49.432	317.119	43.114	330.001
21-Mar	276.805	317.418	74.963	15.989	35.965	65.388	132.296	50.074	318.937	43.365	332.305
22-Mar	278.160	319.930	75.803	16.257	36.567	66.665	133.430	50.716	320.755	43.616	334.610
23-Mar	279.516	322.441	76.644	16.525	37.168	67.943	134.564	51.358	322.573	43.867	336.914
24-Mar	280.872	324.952	77.484	16.792	37.770	69.220	135.698	52.000	324.391	44.118	339.219
25-Mar	282.228	327.464	78.324	17.060	38.371	70.497	136.832	52.642	326.209	44.369	341.523
26-Mar	283.583	329.975	79.165	17.328	38.973	71.774	137.966	53.284	328.027	44.620	343.828
27-Mar	284.939	332.487	80.005	17.595	39.574	73.052	139.100	53.926	329.845	44.871	346.132
28-Mar	286.295	334.998	80.846	17.863	40.175	74.329	140.234	54.568	331.662	45.122	348.437
29-Mar	287.651	337.509	81.686	18.131	40.777	75.606	141.368	55.210	333.480	45.373	350.741
30-Mar	289.006	340.021	82.527	18.398	41.378	76.884	142.503	55.852	335.298	45.624	353.046
31-Mar	290.362	342.532	83.367	18.666	41.980	78.161	143.637	56.494	337.116	45.875	355.350
1-Apr	291.718	345.043	84.207	18.934	42.581	79.438	144.771	57.136	338.934	44.888	357.655
2-Apr	293.073	347.555	85.048	19.201	43.183	80.716	145.905	57.778	340.752	43.900	359.959
3-Apr	294.429	350.066	85.888	19.469	43.784	81.993	147.039	58.420	342.570	42.913	362.264
4-Apr	295.785	352.578	86.729	19.737	44.386	83.270	148.173	59.062	344.388	41.926	364.568
5-Apr	297.141	355.089	87.569	20.005	44.987	84.547	149.307	59.704	346.206	40.938	366.873
6-Apr	298.496	357.600	88.410	20.272	45.589	85.825	150.441	60.346	348.024	39.951	369.177
7-Apr	299.852	360.112	89.250	20.540	46.190	87.102	151.575	60.988	349.842	38.964	371.482
8-Apr	301.208	362.623	90.091	20.808	46.792	88.379	152.709	61.630	351.659	37.977	373.786
9-Apr	302.564	365.135	90.931	21.076	47.393	89.656	153.843	62.272	353.477	36.989	376.091
10-Apr	303.919	367.646	91.772	21.343	47.995	90.934	154.977	62.914	355.295	36.002	378.395
11-Apr	305.275	370.157	92.612	21.611	48.596	92.211	156.112	63.556	357.113	35.015	380.700
12-Apr	306.631	372.669	93.453	21.879	49.198	93.488	157.246	64.198	358.931	34.027	383.004
13-Apr	307.987	375.180	94.293	22.147	49.799	94.765	158.380	64.840	360.749	33.040	385.309
14-Apr	309.342	377.692	95.134	22.414	50.401	96.043	159.514	65.482	362.567	32.053	387.613
15-Apr	310.698	380.203	95.974	22.682	51.002	97.320	160.648	66.124	364.385	31.065	389.918
16-Apr	312.054	382.714	96.814	22.950	51.604	97.320	161.782	66.766	366.203	31.066	392.223
17-Apr	313.409	385.226	97.655	23.217	52.205	97.320	162.916	67.408	368.021	31.066	394.527
18-Apr	314.765	387.737	98.495	23.485	52.807	97.320	164.050	68.050	369.839	31.066	396.832
19-Apr	316.121	390.248	99.336	23.753	53.408	97.320	165.184	68.692	371.657	31.066	399.136
20-Apr	317.477	392.760	100.176	24.020	54.010	97.320	166.318	69.334	373.475	31.066	401.441
21-Apr	318.832	395.271	101.017	24.288	54.611	97.320	167.452	69.976	375.293	31.066	403.745
22-Apr	320.188	397.782	101.857	24.556	55.213	97.320	168.586	70.618	377.111	31.066	406.050
23-Apr	321.544	400.294	102.698	24.823	55.814	97.320	169.721	71.260	378.928	31.066	408.354
24-Apr	322.900	402.805	103.538	25.091	56.415	97.320	170.855	71.902	380.746	31.066	410.659
25-Apr	324.255	405.316	104.379	25.359	57.017	97.320	171.989	72.544	382.564	31.066	412.963
26-Apr	325.611	407.828	105.219	25.626	57.618	97.320	173.123	73.186	384.382	31.066	415.268
27-Apr	326.967	410.339	106.060	25.894	58.220	97.320	174.257	73.828	386.200	31.066	417.572
28-Apr	328.323	412.850	106.900	26.162	58.821	97.320	175.391	74.470	388.018	31.066	419.877
29-Apr	329.678	415.362	107.741	26.429	59.423	97.320	176.525	75.112	389.836	31.066	422.181
30-Apr	331.034	417.873	108.581	26.697	60.024	97.320	177.659	75.754	391.654	31.066	424.486
1-May	332.390	420.384	109.421	26.965	60.626	97.320	178.793	76.396	393.472	31.066	426.791
2-May	333.745	422.896	110.262	27.232	61.227	97.320	179.927	77.039	395.290	31.066	429.095
3-May	335.101	425.407	111.102	27.500	61.829	97.320	181.061	77.681	397.108	31.066	431.400
4-May	336.457	427.919	111.943	27.768	62.430	97.320	182.195	78.323	398.926	31.066	433.704

2-Mar	1499.6	880.6	790.3	766.5	795.8	365.8	1615.1	1291.6	971.6	621.1	1513.9
3-Mar	1500.2	881.3	791.0	766.9	796.5	366.0	1616.4	1292.7	972.2	621.3	1514.8
4-Mar	1500.9	882.0	791.7	767.3	797.2	366.2	1617.6	1293.7	972.9	621.6	1515.7
5-Mar	1501.5	882.8	792.4	767.7	797.8	366.5	1618.9	1294.8	973.5	621.8	1516.6
6-Mar	1502.1	883.5	793.2	768.1	798.4	366.7	1620.1	1295.8	974.1	622.1	1517.5
7-Mar	1502.7	884.3	793.9	768.5	799.0	366.9	1621.4	1296.9	974.7	622.3	1518.4
8-Mar	1503.4	885.0	794.6	768.9	799.7	367.1	1622.6	1297.9	975.3	622.6	1519.2
9-Mar	1504.0	885.7	795.2	769.3	800.3	367.3	1623.8	1298.9	975.9	622.8	1520.1
10-Mar	1504.6	886.4	795.9	769.7	800.9	367.5	1625.0	1299.9	976.5	623.1	1521.0
11-Mar	1505.2	887.2	796.6	770.1	801.5	367.7	1626.2	1300.9	977.1	623.3	1521.8
12-Mar	1505.8	887.9	797.2	770.5	802.0	367.9	1627.4	1301.8	977.7	623.6	1522.7
13-Mar	1506.4	888.6	797.9	770.8	802.6	368.1	1628.6	1302.8	978.3	623.8	1523.6
14-Mar	1507.0	889.3	798.5	771.2	803.2	368.3	1629.8	1303.8	978.9	624.1	1524.4
15-Mar	1507.6	890.0	799.2	771.6	803.8	368.5	1631.0	1304.7	979.4	624.3	1525.3
16-Mar	1508.2	890.7	799.8	771.9	804.3	368.7	1632.2	1305.7	980.0	624.6	1526.1
17-Mar	1508.8	891.4	800.4	772.3	804.9	368.9	1633.4	1306.6	980.6	624.8	1527.0
18-Mar	1509.4	892.1	801.1	772.6	805.4	369.0	1634.5	1307.5	981.2	625.0	1527.8
19-Mar	1510.0	892.8	801.7	773.0	806.0	369.2	1635.7	1308.4	981.8	625.3	1528.6
20-Mar	1510.6	893.5	802.3	773.3	806.5	369.4	1636.9	1309.4	982.4	625.5	1529.4
21-Mar	1511.2	894.2	802.9	773.7	807.1	369.6	1638.0	1310.3	983.0	625.8	1530.3
22-Mar	1511.8	894.9	803.5	774.0	807.6	369.7	1639.2	1311.2	983.5	626.0	1531.1
23-Mar	1512.4	895.6	804.1	774.3	808.1	369.9	1640.3	1312.1	984.1	626.3	1531.9
24-Mar	1513.0	896.3	804.7	774.7	808.6	370.0	1641.5	1313.0	984.7	626.5	1532.7
25-Mar	1513.6	896.9	805.3	775.0	809.1	370.2	1642.6	1313.8	985.3	626.7	1533.5
26-Mar	1514.2	897.6	805.9	775.3	809.7	370.4	1643.8	1314.7	985.8	627.0	1534.3
27-Mar	1514.8	898.3	806.5	775.6	810.2	370.5	1644.9	1315.6	986.4	627.2	1535.2
28-Mar	1515.3	899.0	807.1	775.9	810.7	370.7	1646.0	1316.5	987.0	627.4	1536.0
29-Mar	1515.9	899.6	807.7	776.3	811.2	370.9	1647.1	1317.3	987.5	627.7	1536.7
30-Mar	1516.5	900.3	808.2	776.6	811.7	371.0	1648.2	1318.2	988.1	627.9	1537.5
31-Mar	1517.1	901.0	808.8	776.9	812.1	371.2	1649.3	1319.0	988.7	628.2	1538.3
1-Apr	1517.7	901.6	809.4	777.2	812.6	371.3	1650.4	1319.9	989.2	627.2	1539.1
2-Apr	1518.2	902.3	810.0	777.5	813.1	371.5	1651.5	1320.7	989.8	626.3	1539.9
3-Apr	1518.8	902.9	810.5	777.8	813.6	371.7	1652.6	1321.5	990.3	625.3	1540.7
4-Apr	1519.4	903.6	811.1	778.1	814.1	371.8	1653.7	1322.4	990.9	624.4	1541.5
5-Apr	1520.0	904.3	811.6	778.4	814.5	372.0	1654.8	1323.2	991.5	623.4	1542.2
6-Apr	1520.5	904.9	812.2	778.7	815.0	372.1	1655.9	1324.0	992.0	622.5	1543.0
7-Apr	1521.1	905.6	812.7	779.0	815.4	372.3	1657.0	1324.8	992.6	621.5	1543.8
8-Apr	1521.7	906.2	813.3	779.3	815.9	372.4	1658.0	1325.6	993.1	620.6	1544.5
9-Apr	1522.2	906.9	813.8	779.6	816.3	372.6	1659.1	1326.4	993.7	619.7	1545.3
10-Apr	1522.8	907.5	814.4	779.9	816.8	372.7	1660.2	1327.2	994.2	618.7	1546.0
11-Apr	1523.4	908.1	814.9	780.2	817.2	372.9	1661.2	1328.0	994.8	617.8	1546.8
12-Apr	1523.9	908.8	815.4	780.4	817.7	373.1	1662.3	1328.8	995.3	616.8	1547.5
13-Apr	1524.5	909.4	816.0	780.7	818.1	373.2	1663.3	1329.6	995.9	615.9	1548.2
14-Apr	1525.0	910.1	816.5	781.0	818.5	373.4	1664.4	1330.4	996.4	614.9	1549.0
15-Apr	1525.6	910.7	817.0	781.3	819.0	373.5	1665.4	1331.1	996.9	614.0	1549.7
16-Apr	1526.2	911.3	817.6	781.6	819.4	373.5	1666.4	1331.9	997.5	614.0	1550.4
17-Apr	1526.7	912.0	818.1	781.8	819.8	373.5	1667.5	1332.7	998.0	614.0	1551.1
18-Apr	1527.3	912.6	818.6	782.1	820.2	373.5	1668.5	1333.4	998.6	614.0	1551.8
19-Apr	1527.8	913.2	819.1	782.4	820.6	373.5	1669.5	1334.2	999.1	614.0	1552.6
20-Apr	1528.3	913.8	819.6	782.7	821.1	373.5	1670.5	1335.0	999.6	614.0	1553.3
21-Apr	1528.9	914.5	820.1	782.9	821.5	373.5	1671.5	1335.7	1000.2	614.0	1554.0
22-Apr	1529.4	915.1	820.6	783.2	821.9	373.5	1672.5	1336.5	1000.7	614.0	1554.7
23-Apr	1530.0	915.7	821.2	783.5	822.3	373.5	1673.6	1337.2	1001.2	614.0	1555.4
24-Apr	1530.5	916.3	821.7	783.7	822.7	373.5	1674.6	1337.9	1001.7	614.0	1556.1
25-Apr	1531.1	917.0	822.2	784.0	823.1	373.5	1675.5	1338.7	1002.3	614.0	1556.8
26-Apr	1531.6	917.6	822.7	784.3	823.5	373.5	1676.5	1339.4	1002.8	614.0	1557.4
27-Apr	1532.1	918.2	823.2	784.5	823.8	373.5	1677.5	1340.1	1003.3	614.0	1558.1
28-Apr	1532.7	918.8	823.7	784.8	824.2	373.5	1678.5	1340.9	1003.8	614.0	1558.8
29-Apr	1533.2	919.4	824.2	785.1	824.6	373.5	1679.5	1341.6	1004.4	614.0	1559.5
30-Apr	1533.7	920.0	824.7	785.3	825.0	373.5	1680.5	1342.3	1004.9	614.0	1560.2
1-May	1534.3	920.6	825.1	785.6	825.4	373.5	1681.4	1343.0	1005.4	614.0	1560.8
2-May	1534.8	921.2	825.6	785.8	825.7	373.5	1682.4	1343.7	1005.9	614.0	1561.5
3-May	1535.3	921.8	826.1	786.1	826.1	373.5	1683.4	1344.4	1006.4	614.0	1562.2
4-May	1535.8	922.4	826.6	786.3	826.5	373.5	1684.3	1345.1	1007.0	614.0	1562.8

5-May	337.813	430.430	112.783	28.036	63.032	97.320	183.330	78.966	400.744	31.066	436.009		5-May	1536.4	923.0	827.1	786.6	826.8	373.5	1685.3	1345.8	1007.5	614.0	1563.5
6-May	339.168	432.941	113.624	28.303	63.633	97.320	184.464	79.608	402.561	31.066	436.009		6-May	1536.9	923.6	827.6	786.8	827.2	373.5	1686.2	1346.5	1008.0	614.0	1563.5
7-May	340.524	435.453	114.464	28.571	64.235	97.320	185.598	80.250	404.379	31.066	436.009		7-May	1537.4	924.2	828.1	787.1	827.5	373.5	1687.2	1347.2	1008.5	614.0	1563.5
8-May	341.880	437.964	115.305	28.839	64.836	97.320	186.732	80.892	406.197	31.066	436.009		8-May	1537.9	924.8	828.6	787.3	827.9	373.5	1688.1	1347.9	1009.0	614.0	1563.5
9-May	343.235	440.476	116.145	29.107	65.438	97.320	187.866	81.535	408.015	31.066	436.009		9-May	1538.4	925.4	829.0	787.6	828.3	373.5	1689.1	1348.6	1009.5	614.0	1563.5
10-May	344.591	442.987	116.986	29.374	66.039	97.320	189.000	82.177	409.833	31.066	436.009		10-May	1539.0	926.0	829.5	787.8	828.6	373.5	1690.0	1349.3	1010.0	614.0	1563.5
11-May	345.947	442.987	117.826	29.642	66.641	97.320	189.000	82.820	409.833	31.066	436.009		11-May	1539.5	926.0	830.0	788.1	829.0	373.5	1690.0	1350.0	1010.0	614.0	1563.5
12-May	347.303	442.987	117.826	29.910	67.242	97.320	189.000	82.820	409.833	31.066	436.009		12-May	1540.0	926.0	830.0	788.3	829.3	373.5	1690.0	1350.0	1010.0	614.0	1563.5
13-May	348.658	442.987	117.826	30.178	67.844	97.320	189.000	82.820	409.833	31.066	436.009		13-May	1540.5	926.0	830.0	788.6	829.6	373.5	1690.0	1350.0	1010.0	614.0	1563.5
14-May	350.014	442.987	117.826	30.445	68.445	97.320	189.000	82.820	409.833	31.066	436.009		14-May	1541.0	926.0	830.0	788.8	830.0	373.5	1690.0	1350.0	1010.0	614.0	1563.5
15-May	350.014	442.987	117.826	30.713	69.047	97.320	189.000	82.820	409.833	31.066	436.009		15-May	1541.0	926.0	830.0	789.0	830.3	373.5	1690.0	1350.0	1010.0	614.0	1563.5
16-May	350.014	442.987	117.826	30.981	69.648	97.320	189.000	82.820	409.833	31.066	436.009		16-May	1541.0	926.0	830.0	789.3	830.7	373.5	1690.0	1350.0	1010.0	614.0	1563.5
17-May	350.014	442.987	117.826	31.249	70.250	97.320	189.000	82.820	409.833	31.066	436.009		17-May	1541.0	926.0	830.0	789.5	831.0	373.5	1690.0	1350.0	1010.0	614.0	1563.5
18-May	350.014	442.987	117.826	31.516	70.851	97.320	189.000	82.820	409.833	31.066	436.009		18-May	1541.0	926.0	830.0	789.8	831.3	373.5	1690.0	1350.0	1010.0	618.6	1563.5
19-May	350.014	442.987	117.826	31.784	71.453	97.320	189.000	82.820	409.833	31.066	436.009		19-May	1541.0	926.0	830.0	790.0	831.7	373.5	1690.0	1350.0	1010.0	623.2	1563.5
20-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	31.066	436.009		20-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	627.8	1563.5
21-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	31.066	436.009		21-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	632.4	1563.5
22-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	31.066	436.009		22-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
23-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	31.066	436.009		23-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
24-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	43.470	436.009		24-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
25-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		25-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
26-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		26-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
27-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		27-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
28-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		28-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
29-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		29-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
30-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		30-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
31-May	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		31-May	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
1-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		1-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
2-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		2-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
3-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		3-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
4-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		4-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
5-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		5-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
6-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		6-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
7-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		7-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
8-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		8-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
9-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		9-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
10-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		10-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
11-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		11-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
12-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		12-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
13-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		13-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
14-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		14-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
15-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		15-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
16-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		16-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
17-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		17-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
18-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		18-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
19-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		19-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
20-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		20-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
21-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		21-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
22-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		22-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
23-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		23-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
24-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		24-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
25-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		25-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
26-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		26-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
27-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		27-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
28-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		28-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
29-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		29-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
30-Jun	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		30-Jun	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
1-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		1-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
2-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		2-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
3-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		3-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
4-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		4-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
5-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		5-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
6-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		6-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
7-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009		7-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5

8-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
9-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
10-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
11-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
12-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
13-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
14-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
15-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
16-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
17-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
18-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
19-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
20-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
21-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
22-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
23-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
24-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
25-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
26-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
27-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
28-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
29-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
30-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
31-Jul	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
1-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
2-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
3-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
4-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
5-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
6-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
7-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
8-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
9-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
10-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
11-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
12-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
13-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
14-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
15-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
16-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
17-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
18-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
19-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
20-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
21-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
22-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
23-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
24-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
25-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
26-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
27-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
28-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
29-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
30-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
31-Aug	350.014	442.987	117.826	31.784	72.054	97.320	189.000	82.820	409.833	55.873	436.009	
1-Sep	348.177	439.716	117.826	31.784	72.054	97.320	187.539	82.820	407.465	55.873	433.159	
2-Sep	346.340	436.445	116.402	31.314	70.989	97.320	186.079	81.782	405.097	55.873	430.309	
3-Sep	344.502	433.173	114.978	30.845	69.924	97.320	184.618	80.744	402.729	55.873	427.458	
4-Sep	342.665	429.902	113.555	30.375	68.859	97.320	183.158	79.706	400.361	55.873	424.608	
5-Sep	340.827	426.630	112.131	29.906	67.794	97.320	181.670	78.668	397.993	55.873	421.758	
6-Sep	338.990	423.359	110.707	29.436	66.729	97.320	180.237	77.630	395.625	55.873	418.907	
7-Sep	337.153	420.088	109.283	28.966	65.664	97.320	178.776	76.592	393.257	55.873	416.057	
8-Sep	335.315	416.816	107.860	28.497	64.599	97.320	177.316	75.554	390.889	55.873	413.207	
9-Sep	333.478	413.545	106.436	28.027	63.535	97.320	175.855	74.516	388.520	55.873	410.356	

8-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
9-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
10-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
11-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
12-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
13-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
14-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
15-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
16-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
17-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
18-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
19-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
20-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
21-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
22-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
23-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
24-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
25-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
26-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
27-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
28-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
29-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
30-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
31-Jul	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
1-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
2-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
3-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
4-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
5-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
6-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
7-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
8-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
9-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
10-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
11-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
12-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
13-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
14-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
15-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
16-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
17-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
18-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
19-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
20-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
21-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
22-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
23-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
24-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
25-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
26-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
27-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
28-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
29-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
30-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
31-Aug	1541.0	926.0	830.0	790.0	832.0	373.5	1690.0	1350.0	1010.0	637.0	1563.5
1-Sep	1540.3	925.2	830.0	790.0	832.0	373.5	1688.8	1350.0	1009.3	637.0	1562.7
2-Sep	1539.6	924.5	829.2	789.6	831.4	373.5	1687.6	1348.9	1008.7	637.0	1561.8
3-Sep	1538.9	923.7	828.4	789.2	830.8	373.5	1686.3	1347.8	1008.0	637.0	1561.0
4-Sep	1538.2	922.9	827.6	788.7	830.2	373.5	1685.1	1346.7	1007.4	637.0	1560.2
5-Sep	1537.5	922.1	826.7	788.3	829.6	373.5	1683.8	1345.5	1006.7	637.0	1559.4
6-Sep	1536.8	921.3	825.9	787.9	829.0	373.5	1682.6	1344.4	1006.0	637.0	1558.5
7-Sep	1536.1	920.5	825.1	787.5	828.4	373.5	1681.3	1343.2	1005.3	637.0	1557.7
8-Sep	1535.4	919.8	824.2	787.0	827.8	373.5	1680.1	1342.1	1004.7	637.0	1556.8
9-Sep	1534.7	919.0	823.4	786.6	827.1	373.5	1678.8	1340.9	1004.0	637.0	1556.0

10-Sep	331.641	410.274	105.012	27.558	62.470	97.320	174.395	73.478	386.152	55.873	407.506	
11-Sep	329.803	407.002	103.588	27.088	61.405	97.320	172.934	72.440	383.784	55.873	404.656	
12-Sep	327.966	403.731	102.165	26.619	60.340	97.320	171.474	71.402	381.416	55.873	401.805	
13-Sep	326.128	400.459	100.741	26.149	59.275	97.320	170.013	70.364	379.048	55.873	398.955	
14-Sep	324.291	397.188	99.317	25.679	58.210	97.320	168.553	69.326	376.680	55.873	396.105	
15-Sep	322.454	393.917	97.893	25.210	57.145	97.320	167.082	68.288	374.312	55.873	393.254	
16-Sep	320.616	390.645	96.470	24.740	56.080	97.320	165.632	67.250	371.944	55.873	390.404	
17-Sep	318.779	387.374	95.046	24.271	55.015	97.320	164.171	66.212	369.576	55.873	387.553	
18-Sep	316.942	384.103	93.622	23.801	53.950	97.320	162.711	65.174	367.208	55.873	384.703	
19-Sep	315.104	380.831	92.198	23.331	52.885	97.320	161.250	64.136	364.840	55.873	381.853	
20-Sep	313.267	377.560	90.775	22.862	51.820	97.320	159.789	63.098	362.472	55.873	379.002	
21-Sep	311.429	374.288	89.351	22.392	50.755	95.632	158.329	62.060	360.104	55.873	376.152	
22-Sep	309.592	371.017	87.927	21.923	49.690	93.944	156.868	61.022	357.736	55.873	373.302	
23-Sep	307.755	367.746	86.503	21.453	48.626	92.257	155.408	59.984	355.367	55.873	370.451	
24-Sep	305.917	364.474	85.080	20.984	47.561	90.569	153.947	58.946	352.999	55.873	367.601	
25-Sep	304.080	361.203	83.656	20.514	46.496	88.881	152.487	57.908	350.631	55.873	364.751	
26-Sep	302.243	357.932	82.232	20.044	45.431	87.193	151.026	56.870	348.263	55.873	361.900	
27-Sep	300.405	354.660	80.808	19.575	44.366	85.505	149.566	55.832	345.895	55.873	359.050	
28-Sep	298.568	351.389	79.385	19.105	43.301	83.818	148.105	54.794	343.527	55.873	356.200	
29-Sep	296.730	348.117	77.961	18.636	42.236	82.130	146.648	53.756	341.159	55.873	353.349	
30-Sep	294.893	344.846	76.537	18.166	41.171	80.442	145.184	52.718	338.791	55.873	350.499	
1-Oct	293.056	341.575	75.113	17.696	40.106	78.754	143.724	51.681	336.423	55.334	347.649	
2-Oct	291.218	338.303	73.690	17.227	39.041	77.066	142.263	50.643	334.055	54.794	344.798	
3-Oct	289.381	335.032	72.266	16.757	37.976	75.378	140.803	49.606	331.687	54.255	341.948	
4-Oct	287.543	331.760	70.842	16.288	36.912	73.691	139.342	48.568	329.318	53.716	339.098	
5-Oct	285.706	328.489	69.418	15.818	35.847	72.003	137.882	47.531	326.950	53.177	336.247	
6-Oct	283.869	325.218	67.995	15.348	34.782	70.315	136.421	46.493	324.582	52.637	333.397	
7-Oct	282.031	321.946	66.571	14.879	33.717	68.627	134.961	45.456	322.214	52.098	330.547	
8-Oct	280.194	318.675	65.147	14.409	32.652	66.939	133.500	44.418	319.846	51.559	327.696	
9-Oct	278.356	315.403	63.723	13.940	31.587	65.251	132.039	43.381	317.478	51.020	324.846	
10-Oct	276.519	312.132	62.300	13.470	30.522	63.563	130.579	42.343	315.110	50.480	321.996	
11-Oct	274.682	308.861	60.876	13.000	29.457	61.875	129.118	41.306	312.742	49.941	319.145	
12-Oct	272.844	305.589	59.452	12.531	28.393	60.188	127.658	40.268	310.373	49.402	316.295	
13-Oct	271.007	302.318	58.028	12.061	27.328	58.500	126.197	39.231	308.005	48.863	313.445	
14-Oct	269.169	299.046	56.605	11.592	26.263	56.812	124.737	38.193	305.637	48.323	310.594	
15-Oct	267.332	295.775	55.181	11.122	25.198	55.124	123.276	37.156	303.269	47.784	307.744	
16-Oct	265.495	292.504	53.757	10.652	24.133	53.436	121.816	36.119	300.901	47.245	304.894	
17-Oct	263.657	289.232	52.334	10.183	23.068	51.748	120.355	35.082	298.533	46.705	302.043	
18-Oct	261.820	285.961	50.910	9.713	22.003	50.061	118.895	34.045	296.165	46.166	299.193	
19-Oct	259.983	282.690	49.486	9.244	20.938	48.373	117.434	33.008	293.797	45.627	296.343	
20-Oct	258.145	279.418	48.062	8.774	19.873	46.685	115.974	31.971	291.429	45.087	293.492	
21-Oct	256.308	276.147	46.639	8.305	18.808	44.997	114.513	30.934	289.061	44.548	290.642	
22-Oct	254.470	272.875	45.215	7.835	17.743	43.309	113.053	29.897	286.693	44.009	287.791	
23-Oct	252.633	269.604	43.791	7.366	16.679	41.622	111.592	28.860	284.325	43.470	284.941	
24-Oct	250.796	266.333	42.367	6.896	15.614	39.934	110.132	27.823	281.956	42.930	282.091	
25-Oct	248.958	263.061	40.944	6.426	14.549	38.246	108.671	26.786	279.588	42.391	279.240	
26-Oct	247.121	259.790	39.520	5.957	13.484	36.558	107.211	25.749	277.220	41.852	276.390	
27-Oct	245.284	256.519	38.096	5.487	12.419	34.870	105.750	24.712	274.852	41.312	273.540	
28-Oct	243.446	253.247	36.672	5.018	11.354	33.182	104.289	23.675	272.484	40.773	270.689	
29-Oct	241.609	249.976	35.249	4.548	10.289	31.495	102.829	22.638	270.116	40.234	267.839	
30-Oct	239.771	246.704	33.825	4.079	9.224	29.807	101.368	21.601	267.748	39.694	264.988	
31-Oct	237.934	243.433	32.401	3.609	8.159	28.119	99.908	20.564	265.380	39.155	262.138	
1-Nov	236.097	240.162	30.977	3.139	7.094	26.431	98.447	19.527	263.012	38.616	259.288	
2-Nov	234.259	236.890	29.554	3.139	7.094	24.743	96.987	18.490	260.644	38.076	256.437	
3-Nov	232.422	233.619	28.130	3.139	7.094	23.055	95.526	17.453	258.276	37.537	253.587	
4-Nov	230.584	230.347	26.706	3.139	7.094	21.368	94.066	16.416	255.908	36.998	250.737	
5-Nov	228.747	227.076	25.282	3.139	7.094	19.680	92.605	15.379	253.540	36.459	247.886	
6-Nov	226.910	223.805	23.859	3.139	7.094	17.992	91.145	14.342	251.172	35.919	245.036	
7-Nov	225.072	220.533	22.435	3.139	7.094	16.304	89.684	13.305	248.804	35.380	242.186	
8-Nov	223.235	217.262	21.011	3.139	7.094	14.616	88.224	12.267	246.435	34.841	239.335	
9-Nov	221.397	213.990	19.587	3.139	7.094	12.928	86.763	11.230	244.067	34.302	236.485	
10-Nov	219.560	210.719	18.164	3.139	7.094	11.240	85.303	10.193	241.699	33.762	233.635	
11-Nov	217.723	207.448	16.740	3.139	7.094	9.552	83.842	9.156	239.331	33.223	230.784	
12-Nov	215.885	204.176	15.316	3.139	7.094	7.865	82.382	8.119	236.963	32.684	227.934	

10-Sep	1534.0	918.2	822.5	786.1	826.5	373.5	1677.5	1339.7	1003.3	637.0	1555.1
11-Sep	1533.2	917.4	821.7	785.7	825.8	373.5	1676.2	1338.6	1002.6	637.0	1554.3
12-Sep	1532.5	916.6	820.8	785.2	825.2	373.5	1674.9	1337.4	1001.9	637.0	1553.4
13-Sep	1531.8	915.8	820.0	784.8	824.5	373.5	1673.6	1336.2	1001.3	637.0	1552.5
14-Sep	1531.1	914.9	819.1	784.3	823.8	373.5	1672.3	1335.0	1000.6	637.0	1551.6
15-Sep	1530.3	914.1	818.2	783.9	823.1	373.5	1671.0	1333.7	999.9	637.0	1550.7
16-Sep	1529.6	913.3	817.3	783.4	822.4	373.5	1669.7	1332.5	999.2	637.0	1549.8
17-Sep	1528.9	912.5	816.5	782.9	821.7	373.5	1668.3	1331.3	998.5	637.0	1548.9
18-Sep	1528.1	911.7	815.6	782.4	821.0	373.5	1667.0	1330.0	997.8	637.0	1548.0
19-Sep	1527.4	910.9	814.6	782.0	820.3	373.5	1665.7	1328.7	997.1	637.0	1547.1
20-Sep	1526.6	910.0	813.7	781.5	819.5	373.5	1664.3	1327.4	996.4	637.0	1546.2
21-Sep	1525.9	909.2	812.8	781.0	818.8	373.3	1662.9	1326.2	995.7	637.0	1545.3
22-Sep	1525.1	908.4	811.9	780.5	818.0	373.1	1661.6	1324.9	994.9	637.0	1544.4
23-Sep	1524.4	907.5	810.9	780.0	817.2	372.9	1660.2	1323.5	994.2	637.0	1543.4
24-Sep	1523.6	906.7	810.0	779.5	816.5	372.7	1658.8	1322.2	993.5	637.0	1542.5
25-Sep	1522.9	905.8	809.0	779.0	815.7	372.5	1657.4	1320.9	992.8	637.0	1541.5
26-Sep	1522.1	905.0	808.0	778.4	814.9	372.3	1656.0	1319.5	992.1	637.0	1540.6
27-Sep	1521.3	904.1	807.1	777.9	814.0	372.1	1654.6	1318.1	991.4	637.0	1539.6
28-Sep	1520.6	903.3	806.1	777.4	813.2	371.9	1653.2	1316.8	990.6	637.0	1538.6
29-Sep	1519.8	902.4	805.1	776.9	812.3	371.7	1651.8	1315.4	989.9	637.0	1537.6
30-Sep	1519.0	901.6	804.0	776.3	811.5	371.5	1650.4	1313.9	989.2	637.0	1536.7
1-Oct	1518.2	900.7	803.0	775.7	810.6	371.3	1648.9	1312.5	988.4	636.5	1535.7
2-Oct	1517.5	899.8	802.0	775.2	809.7	371.0	1647.5	1311.1	987.7	636.1	1534.7
3-Oct	1516.7	899.0	800.9	774.6	808.8	370.8	1646.0	1309.6	987.0	635.6	1533.7
4-Oct	1515.9	898.1	799.9	774.0	807.9	370.6	1644.6	1308.1	986.2	635.2	1532.7
5-Oct	1515.1	897.2	798.8	773.4	806.9	370.4	1643.1	1306.6	985.5	634.7	1531.7
6-Oct	1514.3	896.3	797.7	772.8	806.0	370.2	1641.6	1305.1	984.7	634.2	1530.7
7-Oct	1513.5	895.4	796.6	772.2	805.0	370.0	1640.1	1303.6	984.0	633.8	1529.6
8-Oct	1512.7	894.5	795.5	771.6	804.0	369.8	1638.6	1302.0	983.2	633.3	1528.6
9-Oct	1511.9	893.6	794.3	771.0	803.0	369.6	1637.1	1300.4	982.5	632.8	1527.6
10-Oct	1511.1	892.7	793.1	770.3	802.0	369.3	1635.6	1298.8	981.7	632.4	1526.6
11-Oct	1510.3	891.8	791.9	769.6	801.0	369.1	1634.1	1297.2	981.0	631.9	1525.5
12-Oct	1509.5	890.9	790.7	769.0	799.9	368.8	1632.5	1295.5	980.2	631.4	1524.5
13-Oct	1508.7	890.0	789.4	768.3	798.8	368.6	1631.0	1293.8	979.4	630.9	1523.4
14-Oct	1507.8	889.1	788.1	767.6	797.7	368.4	1629.4	1292.1	978.7	630.4	1522.3
15-Oct	1507.0	888.1	786.9	766.8	796.6	368.1	1627.9	1290.3	977.9	629.9	1521.3
16-Oct	1506.2	887.2	785.6	766.1	795.4	367.8	1626.3	1288.5	977.1	629.4	1520.2
17-Oct	1505.4	886.3	784.3	765.3	794.2	367.6	1624.7	1286.7	976.3	628.9	1519.1
18-Oct	1504.5	885.3	783.0	764.6	792.9	367.3	1623.2	1284.8	975.6	628.4	1518.0
19-Oct	1503.7	884.4	781.7	763.8	791.7	367.0	1621.6	1282.8	974.8	627.9	1516.9
20-Oct	1502.9	883.4	780.4	763.0	790.4	366.8	1620.0	1280.8	974.0	627.4	1515.8
21-Oct	1502.0	882.5	779.0	762.1	789.0	366.5	1618.3	1278.8	973.2	626.9	1514.7
22-Oct	1501.2	881.5	777.6	761.3	787.6	366.2	1616.7	1276.7	972.4	626.4	1513.6
23-Oct	1500.4	880.5	776.2	760.4	786.2	365.9	1615.1	1274.5	971.6	625.9	1512.5
24-Oct	1499.5	879.5	774.8	759.5	784.7	365.6	1613.4	1272.2	970.8	625.4	1511.4
25-Oct	1498.7	878.6	773.3	758.5	783.1	365.3	1611.8	1269.9	970.0	624.8	1510.2
26-Oct	1497.8	877.6	771.7	757.6	781.5	364.9	1610.1	1267.5	969.2	624.3	1509.1
27-Oct	1496.9	876.6	770.1	756.5	779.8	364.6	1608.4	1265.0	968.4	623.8	1507.9
28-Oct	1496.1	875.6	768.5	755.4	778.1	364.2	1606.7	1262.4	967.6	623.3	1506.7
29-Oct	1495.2	874.6	766.8	754.2	776.3	363.9	1605.0	1259.6	966.8	622.7	1505.6
30-Oct	1494.3	873.5	765.1	752.9	774.4	363.5	1603.3	1256.8	965.9	622.2	1504.4
31-Oct	1493.4	872.5	763.3	751.5	772.5	363.1	1601.6	1253.9	965.1	621.6	1503.2
1-Nov	1492.6	871.5	761.5	750.0	770.5	362.7	1599.8	1250.8	964.3	621.1	1502.0
2-Nov	1491.7	870.4	759.7	750.0	770.5	362.3	1598.1	1247.6	963.4	620.5	1500.8
3-Nov	1490.8	869.4	757.8	750.0	770.5	361.9	1596.3	1244.3	962.6	620.0	1499.6
4-Nov	1489.9	868.3	755.8	750.0	770.5	361.4	1594.6	1240.8	961.7	619.4	1498.3
5-Nov	1489.0	867.3	753.8	750.0	770.5	360.9	1592.8	1237.2	960.9	618.8	1497.1
6-Nov	1488.1	866.2	751.7	750.0	770.5	360.4	1591.0	1233.4	960.0	618.3	1495.9
7-Nov	1487.2	865.1	749.5	750.0	770.5	359.9	1589.1	1229.4	959.2	617.7	1494.6
8-Nov	1486.2	864.0	747.4	750.0	770.5	359.4	1587.3	1225.2	958.3	617.1	1493.3
9-Nov	1485.3	862.9	745.2	750.0	770.5	358.8	1585.5	1220.8	957.4	616.5	1492.0
10-Nov	1484.4	861.8	742.9	750.0	770.5	358.1	1583.6	1216.2	956.5	616.0	1490.7
11-Nov	1483.5	860.7	740.7	750.0	770.5	357.4	1581.7	1211.3	955.6	615.4	1489.4
12-Nov	1482.5	859.6	738.5	750.0	770.5	356.5	1579.8	1206.0	954.8	614.8	1488.1

13-Nov	214.048	200.905	13.892	3.139	7.094	6.177	80.921	7.082	234.595	32.145	225.084	
14-Nov	212.210	197.633	12.469	3.139	7.094	4.489	79.461	6.045	232.227	31.605	222.233	
15-Nov	210.373	194.362	11.045	3.139	7.094	2.801	78.000	5.008	229.859	31.066	219.383	
16-Nov	206.706	189.322	9.621	3.139	7.094	2.801	76.280	3.970	228.337	31.066	215.050	
17-Nov	203.040	184.282	9.621	3.139	7.094	2.801	74.560	3.970	226.815	31.066	210.716	
18-Nov	199.373	179.242	9.621	3.139	7.094	2.801	72.840	3.970	225.293	31.066	206.383	
19-Nov	195.706	174.202	9.621	3.139	7.094	2.801	71.120	3.970	223.771	31.066	202.050	
20-Nov	192.040	169.162	9.621	3.139	7.094	2.801	69.400	3.970	222.249	31.066	197.716	
21-Nov	188.373	164.122	9.621	3.139	7.094	2.801	67.680	3.970	220.727	31.066	193.383	
22-Nov	184.706	159.082	9.621	3.139	7.094	2.801	65.960	3.970	219.205	31.066	189.050	
23-Nov	181.040	154.042	9.621	3.139	7.094	2.801	64.240	3.970	217.683	31.066	184.716	
24-Nov	177.373	149.002	9.621	3.139	7.094	2.801	62.520	3.970	216.161	31.066	180.383	
25-Nov	173.706	143.962	9.621	3.139	7.094	2.801	60.800	3.970	214.639	31.066	176.050	
26-Nov	170.040	138.922	9.621	3.139	7.094	2.801	59.080	3.970	213.117	31.066	171.716	
27-Nov	166.373	133.882	9.621	3.139	7.094	2.801	57.360	3.970	211.595	31.066	167.383	
28-Nov	162.706	128.842	9.621	3.139	7.094	2.801	55.640	3.970	210.073	31.066	163.050	
29-Nov	159.040	123.802	9.621	3.139	7.094	2.801	53.920	3.970	208.551	31.066	158.716	
30-Nov	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	207.029	31.066	154.383	
1-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	205.507	31.066	154.383	
2-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	203.986	31.066	154.383	
3-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	202.464	31.066	154.383	
4-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	200.943	31.066	154.383	
5-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	199.421	31.066	154.383	
6-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	197.899	31.066	154.383	
7-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	196.378	31.066	154.383	
8-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	194.856	31.066	154.383	
9-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	193.334	31.066	154.383	
10-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	191.813	31.066	154.383	
11-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	190.291	31.066	154.383	
12-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	188.770	31.066	154.383	
13-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	187.248	31.066	154.383	
14-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	185.726	31.066	154.383	
15-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	184.205	31.066	154.383	
16-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	182.683	31.066	154.383	
17-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	181.162	31.066	154.383	
18-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	179.640	31.066	154.383	
19-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	178.118	31.066	154.383	
20-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	176.597	31.066	154.383	
21-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	175.075	31.066	154.383	
22-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	173.554	31.066	154.383	
23-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	172.032	31.066	154.383	
24-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	170.510	31.066	154.383	
25-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	168.989	31.066	154.383	
26-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	167.467	31.066	154.383	
27-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	165.945	31.066	154.383	
28-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	164.424	31.066	154.383	
29-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	162.902	31.066	154.383	
30-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	161.381	31.066	154.383	
31-Dec	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383	
1-Jan	155.373	118.762	9.621	3.139	7.094	2.801	52.200	3.970	159.859	31.066	154.383	

13-Nov	1481.6	858.4	736.1	750.0	770.5	355.6	1577.9	1200.3	953.9	614.2	1486.8
14-Nov	1480.6	857.3	733.6	750.0	770.5	354.5	1576.0	1194.1	953.0	613.6	1485.5
15-Nov	1479.7	856.1	730.9	750.0	770.5	353.0	1574.1	1187.4	952.0	613.0	1484.1
16-Nov	1477.8	854.3	728.0	750.0	770.5	353.0	1571.5	1180.0	951.5	613.0	1482.0
17-Nov	1475.8	852.4	728.0	750.0	770.5	353.0	1568.9	1180.0	950.9	613.0	1479.9
18-Nov	1473.9	850.6	728.0	750.0	770.5	353.0	1566.2	1180.0	950.3	613.0	1477.7
19-Nov	1471.9	848.7	728.0	750.0	770.5	353.0	1563.6	1180.0	949.7	613.0	1475.6
20-Nov	1469.8	846.7	728.0	750.0	770.5	353.0	1560.9	1180.0	949.1	613.0	1473.4
21-Nov	1467.8	844.7	728.0	750.0	770.5	353.0	1558.2	1180.0	948.5	613.0	1471.2
22-Nov	1465.7	842.7	728.0	750.0	770.5	353.0	1555.4	1180.0	947.9	613.0	1468.9
23-Nov	1463.6	840.7	728.0	750.0	770.5	353.0	1552.6	1180.0	947.3	613.0	1466.7
24-Nov	1461.5	838.6	728.0	750.0	770.5	353.0	1549.8	1180.0	946.7	613.0	1464.4
25-Nov	1459.3	836.4	728.0	750.0	770.5	353.0	1546.9	1180.0	946.1	613.0	1462.1
26-Nov	1457.1	834.2	728.0	750.0	770.5	353.0	1544.0	1180.0	945.4	613.0	1459.7
27-Nov	1454.8	832.0	728.0	750.0	770.5	353.0	1541.1	1180.0	944.8	613.0	1457.3
28-Nov	1452.6	829.7	728.0	750.0	770.5	353.0	1538.1	1180.0	944.2	613.0	1454.9
29-Nov	1450.3	827.4	728.0	750.0	770.5	353.0	1535.1	1180.0	943.6	613.0	1452.5
30-Nov	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	943.0	613.0	1450.0
1-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	942.3	613.0	1450.0
2-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	941.7	613.0	1450.0
3-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	941.1	613.0	1450.0
4-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	940.4	613.0	1450.0
5-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	939.8	613.0	1450.0
6-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	939.2	613.0	1450.0
7-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	938.5	613.0	1450.0
8-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	937.9	613.0	1450.0
9-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	937.2	613.0	1450.0
10-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	936.6	613.0	1450.0
11-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	935.9	613.0	1450.0
12-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	935.2	613.0	1450.0
13-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	934.6	613.0	1450.0
14-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	933.9	613.0	1450.0
15-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	933.2	613.0	1450.0
16-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	932.6	613.0	1450.0
17-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	931.9	613.0	1450.0
18-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	931.2	613.0	1450.0
19-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	930.5	613.0	1450.0
20-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	929.8	613.0	1450.0
21-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	929.1	613.0	1450.0
22-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	928.4	613.0	1450.0
23-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	927.7	613.0	1450.0
24-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	927.0	613.0	1450.0
25-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	926.3	613.0	1450.0
26-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	925.6	613.0	1450.0
27-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	924.9	613.0	1450.0
28-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	924.2	613.0	1450.0
29-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	923.5	613.0	1450.0
30-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.7	613.0	1450.0
31-Dec	1448.0	825.0	728.0	750.0	770.5	353.0	1532.0	1180.0	922.0	613.0	1450.0
							1532.0				

Appendix D

Willamette Mainstem Flow Operations Strategy

Submitted by:
U.S. Army Corps of Engineers, Portland District
Bonneville Power Administration
Bureau of Reclamation

Submitted to:
National Marine Fisheries Service
U.S. Fish and Wildlife Service

Final May 2007

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Willamette Mainstem Flow Operations Strategy

1. Introduction

In March 2001, the National Marine Fisheries Service (NMFS) provided to the Portland District, U.S. Army Corps of Engineers (USACE) preliminary drafts of Reasonable and Prudent Alternative (RPA) and Incidental Take Statement (ITS) sections of a joint [with the U.S. Fish and Wildlife Service (USFWS), in combination called the Services] draft Willamette Project Biological Opinion (BiOp) for review and comment [1]. The second measure under the draft BiOp's RPA dealt with continuation (since 1999) of the spring and early summer mainstem minimum flow levels (i.e. biological flow objectives) needed to support salmon and steelhead migration.

In the Portland District response back to the Services, concern was expressed that under drier than average conditions (such as were experienced in 2001), it would be impossible to implement the proposed flow objectives. The USACE agreed to develop a decision-making protocol and operational criteria for meeting the flow objectives across a range of different hydrologic conditions for further consideration by the Services.

This paper describes the conceptual basis for an approach to operating the Willamette projects in a way that will satisfy the biological requirements for mainstem flows for species listed under the Endangered Species Act (ESA) while allowing the USACE to continue to meet, when possible, other authorized project purposes across a range of varying annual hydrologic conditions. The intent of this paper is to promote coordination between the Action Agencies [USACE, Bonneville Power Administration (BPA) and Bureau of Reclamation (Reclamation)] and the Services regarding possible alternative flow management approaches.

At the time of this update, the USACE has successfully implemented the essential aspects of this flow management strategy since the year 2000. Over the ensuing time period, the interagency process used to implement the operating strategy each year has continued to evolve and mature. We anticipate that this cooperative process will continue into the foreseeable future. The Action Agencies have used monthly meetings and weekly coordination teleconferences to provide updates on current environmental and flow conditions in the Willamette Basin and to discuss appropriate courses of action over the ensuing management period.

2. Spring Mainstem Flow Objectives

Starting in 2000, the Services recommended implementation of biologically based, weekly average and instantaneous minimum flow objectives for the Willamette River at Salem, Oregon. These flows are defined for April 1 to June 30 (Table D-1) each year. The biological minimum flow objectives were first recommended by Oregon Department of Fish and Wildlife (ODFW) and then recognized and adopted by the Services. They were the basis of consideration for operations beginning in 1999, through to the present.

[1] Federal Review Draft – Biological and Conference Opinion on the Effects of the Operation of 13 Flood Control Dams and Maintenance of 93 Miles of Streambank Revetments, Upper Willamette Basin, Oregon, on various fishery. USACE, NMFS, and USFWS, September 22, 2000.

Table D-1. Biological Minimum Flow Objectives for the Willamette River at Salem from April 1 to June 30

Time Period	Weekly Average Minimum Flow (cfs)	Instantaneous Minimum Flow (cfs)
April 1-15	17,800	14,300
April 16-30	17,800	14,300
May 1-31	15,000	12,000
June 1-15	13,000	10,500
June 16-30	8,700	7,000

The USACE was unable to meet all of the flow objectives in 2001 because of extreme low water conditions that year. The biological minimum flow objectives are based on the best currently available information regarding the biological needs of ESA-listed fish species, as described in a report prepared by the ODFW.[2] The NMFS Science Center has reviewed the ODFW research and concurs with the mainstem flow objectives as biologically justified. In addition to April through June flow objectives for fish, the Services recognized the need for continuation of the summer and fall (June-October) flows shown in Table D-2. Continuation of the minimum flow at Albany in the summer is important for meeting the USACE responsibility to help in maintaining suitable water quality.

Table D-2. Congressionally Authorized Minimum Flow Objectives for the Willamette River at Salem and at Albany (extending September flow objective through October 31)

Time Period	Average Flow at Albany (cfs)	Average Flow at Salem(cfs)
June 1-30	4,500	N/A
July 1-31	4,500	6,000
August 1-15	5,000	6,000
August 16-31	5,000	6,500
September 1-30	5,000	7,000
October 1-31	5,000	7,000

3. Effectiveness Monitoring

Monitoring, evaluation and reporting requirements related to the provision of mainstem flows will be developed in collaboration with the Services and may be incorporated into the BiOps. It is important to recognize that the mainstem spring flow objectives described in Table 1 may be temporary actions and are subject to review and revision in accordance with the results of appropriate monitoring and evaluation.

[2] Biological and Technical Justification for the Willamette River Flow Proposal of the Oregon Department of Fish and Wildlife, Mamoyac, Buckman, and Tinus, Draft August 8, 2000.

4. Definition of Key Terms

"Biological minimum flow objective" refers to the minimum level of flow that the fisheries agencies have indicated are needed for migrating adult and juvenile salmon and steelhead during the spring (April through June) runoff period. Spring biological flow objectives for fish are based on the best currently available scientific information. The spring flow objectives, or minimum levels of flow recommended to sustain anadromous fish populations in the Willamette Basin on a long-term basis, do not change based on the availability of water. When possible, it is preferable for mainstem Willamette River flows to exceed these biological minimum flow objectives. However, in some years there will be insufficient water available to meet the flow objectives.

"Congressionally authorized minimum flow objectives" during summer and fall (July through September), as measured in the mainstem Willamette River at Salem and at Albany are those that were included in the original formulation and authorization of the Willamette System Project. The Congressionally authorized flow levels during summer and fall were originally based on depths for navigation in the Willamette. They have become base flows used to maintain water quality standards in the mainstem Willamette. Minimum flow objectives for September have been used through low flow periods extending into October.

"Operational flow target" refers to the actual level of flow that managers will attempt to achieve during a given time period in the mainstem Willamette River at Salem. Flow targets are guided by corresponding flow objectives but may differ from them depending on the availability of water in any given water year and on other operational constraints and concerns. Flow targets will meet or exceed biological minimum flow objectives whenever possible. In low flow years, flow targets may be less than their corresponding biological flow objectives. This strategy recognizes that even under natural (i.e. unaltered) environmental conditions, there were some years in which flows were insufficient to meet the flow needs of migrating fish populations.

"Deficit flow thresholds" were those used (achieved or exceeded) on the mainstem Willamette River at Salem during the 2001 water year. This water year was the driest encountered to date since implementation of this flow management strategy in 2000. These 2001 flow levels were agreed upon following extensive hydrologic modeling analysis and multi-agency efforts to carefully balance risks associated with the multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed species. The flow levels were developed under the ongoing ESA Section 7 consultation activity. Use of the Deficit Flow Thresholds recognizes, in part, the historic physical limitations of the Willamette Basin ecosystem over the period of record. However, 16% of the period-of-record years have actually been drier than 2001.

"Storage volume targets" are those volumes of system-wide storage (with regard to the combined Willamette River federal projects) that are determined to be necessary to meet specified project purposes in a particular type of water year. Storage volume targets are defined for four levels of storage availability: "deficit," "insufficient," "adequate," and "abundant." The Willamette Valley Project total available active storage is 1.594 million acre feet (MAF). Table D-3 identifies the storage ranges for each of these levels by May 10-20 of any given year.

"Interim draft limits" are storage limits that the projects will be operated at, or above, in order to meet minimum tributary and mainstem flows later in the summer and early fall months. These limits will be most important in the "insufficient" and "deficit" runoff years when a balance between spring and summer flows will be more difficult to manage.

5. Willamette Conservation Plan Development

The designation of a conservation season runoff forecast as abundant, adequate, insufficient, or deficit will lead to differing management tactical approaches. Table D-3[3] summarizes the designation of Willamette Basin runoff observed over a 64-year period of record.

Table D-3. Evaluation of Spring Runoff and Conservation Operation (period of record 1936-1999 using Tables 1 and 2 flow objectives)

Volume in Storage by 10-20 May (MAF)	Designation	Occurrences (years)	Percent of Years
< 900	Deficit	10	16
900 – 1.19	Insufficient	6	9
1.20 – 1.48	Adequate	11	17
> 1.48	Abundant	37	58
1.59	Maximum *	---	---

* Maximum useable conservation storage. Total transient system storage is somewhat more.

For years designated as **abundant** or **adequate**, minimum flow objectives during spring, summer, and fall (Tables D-1 and D-2) would be met or exceeded whenever possible (e.g., considering factors such as the accuracy of weather forecasts, constraints in the accuracy of operational adjustments at dams, and delayed system response time between the points of storage release and Salem). During an **insufficient** runoff season, it will likely be necessary to reduce flow targets at Salem and Albany to levels below the biological and Congressional minimum flow objectives. The flow targets would be less than the minimum flow objectives, proportional to the expected mid-May system-wide storage capability, down to a minimum of the deficit flow thresholds shown in Table D-4. For **deficit** runoff years, it is unlikely that even the weekly average deficit flow thresholds (Table D-4) would be attainable. Extensive coordination, cooperation, and adaptive management will be required in such years to balance storage use between flows needed to protect ESA-listed fish species and other uses. In both insufficient and deficit runoff years, it will be increasingly important to balance flows needed to protect ESA-listed fish species against other uses that, in general, are important for protecting human health and safety (e.g., maintaining water quality later in the year). Reservoir-specific draft limits will likely constrain flow releases in such years. Four of the 10 identified deficit years (from 1936-1999) resulted in less than 600,000 acre-feet of storage by mid-May.

Abundant. An *abundant* system-wide conservation storage volume is characterized by the expectation of having greater than 1.48 MAF in system storage by mid-May and having a relatively high probability of filling the three high-priority recreation reservoirs (Detroit, Fern Ridge, and Foster) throughout the summer (May through August) while fully meeting flow objectives at Salem (see Tables D-1 and D-2). When hydrologic modeling indicates that the system-wide storage volume is expected to reach or exceed 1.48 MAF between 10-20 May, weekly average flow targets will be established which fully meet or exceed the biological minimum flow objectives shown in Table D-1. Due to the high level of runoff, it is anticipated that these objectives would be exceeded without specific operational input. Under these

[3] This information was developed using HEC-5 reservoir system operation model of the Willamette Project. The results are based on meeting unmodified biological minimum flow objectives regardless of effects on other authorized purposes. Details are published in a study report.

conditions, it is expected that all lakes will fill at close to the prescribed (i.e., rule curve) rate while passing additional flow downstream. Lower priority recreation reservoirs could be drafted later in the summer to meet flow objectives, possibly reducing the extent of their recreation season.

Table D-4. Weekly Average Minimum Flow Objectives and Minimum Deficit Flow Targets for the Willamette River at Salem

Time Period	Minimum Flow Objective Weekly Averages (Biological and Congressional from Tables 1 & 2 in cfs)	Deficit Flow Threshold Weekly Averages (based on 2001 flows in cfs)
April 1-15	17,800	15,000
April 16-30	17,800	15,000
May 1-31	15,000	15,000
June 1-15	13,000	11,000
June 16-30	8,700	5,500
July 1-31	6,000	5,000
August 1-15	6,000	5,000
August 16-31	6,500	5,000
September 1-30	7,000	5,000
October 1-31	7,000	5,000

Adequate. An adequate system-wide conservation storage volume is characterized by the expectation of having 1.20 to 1.48 MAF in system storage by mid-May and having a relatively high probability of filling the three high-priority recreation reservoirs through most but not necessarily all of the summer while fully meeting flow objectives at Salem (see Tables D-1 and D-2). In these years, it is anticipated that spring flow objectives on the mainstem Willamette at Salem will be met or exceeded to enhance survival of migrating listed species. When it is determined that 1.20 MAF has been stored on or before mid-May, we will continue to store additional water on a system-wide basis only when we are exceeding mainstem flow objectives at Salem (Table D-1) by at least 10% (e.g., when we are meeting or exceeding 16,500 cfs in May).

Insufficient and Deficit. For these categories, there would not be a sufficient amount of runoff to meet all of the flow objectives in Tables D-1 and D-2 while permitting high priority Willamette reservoirs to fill to a level that would support recreational use throughout most of the summer. This situation occurs when the system-wide conservation storage level in the Willamette Basin is not anticipated to reach 1.20 MAF by mid-May. Below this level of system-wide conservation storage, inflow to reservoirs will be shared between that needed for storage to address summer and fall flow targets. Reservoir-specific interim draft limits will be used to avoid over-draft of stored water during the early part of the flow management season.

An insufficient designation for system-wide conservation storage volume occurs when the anticipated storage by mid-May is expected to be between 0.90 and 1.20 MAF, while attempting to fully meet biological and Congressional minimum flow objectives presented in Tables D-1 and D-2. In these years, mainstem operational flow targets for spring, summer, and fall will be based on a sliding-scale proportion of the minimum flow objectives presented in Table D-4 between minimum flow objectives and deficit flow thresholds. The proportion of flow provided between the minimum flow objectives and the deficit flow thresholds will be equal to the proportion of system-wide storage anticipated to be obtained by mid-May between 0.90 MAF and 1.20 MAF. This threshold volume is based on results of water management actions implemented in 2001 to carefully balance risks associated with the multiple uses for Willamette Basin flow and storage, including the needs of ESA-listed fish species.

A deficit designation occurs when the runoff season is so low that the projected system storage by mid May is less than 0.90 MAF. Under these circumstances, it may not be possible to meet the biological and Congressional minimum flow objectives in Tables D-1 and D-2. Mainstem operational flow targets for spring, summer, and fall will be determined through the annual Willamette Conservation Plan development process, as described below, but are likely to be below the deficit flow thresholds shown in Table D-4. Under such severe conditions, coordination, cooperation, and adaptive management based on modeling of reservoir inflow and releases and on use of interim reservoir draft limits will be used to monitor and adjust flows, balance needs, and minimize impacts to ESA-listed fish species while meeting other water uses related, in general, to human health and safety. It will be especially important during deficit years to balance needs for flows during spring to support spawning and incubation of ESA-listed winter steelhead with needs for storage to provide flows during summer for water quality and during fall for spawning and incubation of ESA-listed spring Chinook salmon.

In both insufficient and deficit year cases, storage for recreational use would be considered a low priority. Hydropower generation, irrigation, and other authorized uses will be met to the fullest extent possible through both discharges of reservoir inflows during spring and release of storage during summer and fall to meet mainstem flow management targets. Priority will be given to those flow needs directly related to human health and safety. Reservoir inflow in excess of that needed to meet the mainstem operational flow targets during spring will be stored in a manner that maximizes the likelihood of being able to meet minimum discharge rates, mainstem Willamette River flow objectives at Albany and Salem during June through October, and Willamette Basin hydropower production needs.

6. Flow Management Coordination

As required by Congressional authorities, the USACE has traditionally managed the Willamette Project to meet multiple responsibilities, including flood control, power production, pollution abatement, recreation, irrigation, municipal and industrial water supply, navigation, and conservation of fish and wildlife within the project area. The approach in this strategy will help to meet the USACE responsibility under the ESA to avoid jeopardy to the continued existence of ESA-listed fish species. In making operational decisions to meet the requirements of the ESA, the Action Agencies must take all appropriate actions within their authorities to protect ESA-listed species. In some years, water resources will be insufficient to completely meet all of the traditional USACE responsibilities as well as the ESA responsibilities for the Willamette Project.

In accordance with individual project operation limits, the USACE prepares each year an operating plan for the conservation storage and release seasons (February-October) in the Willamette Basin. This plan is called the Willamette Conservation Plan (WCP). The WCP describes how the authorized project purposes will be accomplished during the conservation storage and release seasons given the volume of water forecasted to be available during the water year. The preparation of the WCP is initiated in January following the release of the initial water supply forecast for the basin from the Natural Resources Conservation Service (NRCS). The WCP is finalized by late May. Historically, the USACE has prepared the WCP in coordination with state and federal agencies, including the Services. In the future, it is anticipated that a technical Flow Management (FM) Committee of the Willamette Action Team for Ecosystem Restoration (WATER) will play a key role in coordinating with the USACE for development of the WCP.

Willamette Action Team for Ecosystem Restoration (WATER). The preliminary draft BiOps called on the USACE to convene a forum of the Action Agencies, Services and other agencies responsible for planning and implementing flow management in the Willamette Basin. Among other actions, WATER will be responsible for working with the USACE to coordinate annual development of the WCP and real-time operations for the projects during the conservation season (April through October). It is anticipated that a flow management subcommittee of WATER will supplant the ad-hoc interagency committee that has been coordinating with the USACE on Willamette Project operations since 1999.

Flow Management Planning. The following paragraphs describe a protocol for developing the WCP across a full range of water years. The protocol is based on adaptive management that will spread risk of insufficient water among all authorized project purposes. Included among these uses are minimum tributary flows needed to protect ESA-listed fish species.

Adaptive management of flows involves making adjustments to reservoir operations and flow releases based on current and forecasted hydrologic conditions and will spread risk of insufficient water among all authorized project purposes. These purposes are described in detail in Chapter 2 of the USACE Willamette Project Biological Assessment (BA; update to new BA supplement)[4]. The Services, Action Agencies, and other WATER members will continue to work cooperatively each year during the conservation storage and release season to adjust flows to meet requirements of ESA species and other project purposes. Adaptive management is preferable to establishing fixed operating criteria because the Willamette Basin is a highly rain-dependent system with variable springtime flows. Current forecast methods do not differentiate between the significant contribution of snowmelt and the highly variable rainfall contribution. It is not possible to foresee, describe, and model all of the possible management scenarios and contingencies.

Under the protocol, beginning in or before January of each year, the USACE will determine if there is likely to be a sufficient volume of water in the Willamette Basin throughout the conservation season (February through October) to meet all of the identified flow and storage needs, including both the spring minimum flow objectives in Table D-1 and Congressionally authorized summer and fall flow objectives in Table D-2. Development of a flow management plan for the conservation season will be guided by the forecasted availability of water. It is important to recognize that in a rain-driven system like the Willamette Basin the best available hydrologic modeling early in the season may result in forecasts that differ significantly from actual conditions later in the conservation season. Since the plan calls for setting operational flow targets at Salem beginning on April 1, based on a storage forecast for mid-May, flows may be adjusted through the season. The availability of water will be re-assessed monthly or as necessary during January through May and related changes in management strategy will be made.

The USACE will use hydrologic modeling techniques to convert water supply forecasts for the Willamette Basin, provided by the NRCS, and perhaps other sources into an estimate of runoff volume available for the ensuing conservation management season. The estimate of runoff

[4] Biological Assessment of the Effects of the Willamette River Basin Flood Control Project on Species Listed Under the Endangered Species Act; Portland District, USACE, April 2000.

volume will be used to guide development of an annual flow management operational plan (WCP). The WCP will estimate mainstem flows and reservoir storage volumes likely to occur over the conservation season based on system operational alternatives and constraints. Consideration will be given to system operational constraints and to the resulting operation of the USACE Willamette reservoirs for the impending spring, summer, and fall periods. The modeling will consider the likelihood of meeting the spring flow objectives in Table D-1 and the Congressionally authorized summer and fall flow objectives at Salem and Albany in Table D-2, in conjunction with the likelihood that each of the reservoirs will fill.

7. Strategy Statement

The operational flow targets as determined under the process described above, and the associated flow management guidelines, are intended to balance the risks to listed fish species under low water year conditions with the risks to other uses authorized by Congress for the Willamette Valley Project. Key among these authorized uses are those significant to human health and safety. These include flood damage reduction, hydropower production for use within the Willamette Basin, and summer and fall low flow augmentation for maintenance of local water supply and water quality.

Appendix E
Biological Requirements & the Viability of Anadromous Salmonid Populations
Rangewide Status

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Appendix E

BIOLOGICAL REQUIREMENTS & THE VIABILITY OF ANADROMOUS SALMONID POPULATIONS

The following sections describe, in general terms that apply throughout the action area for this consultation, the relationships between biological requirements and the viability of anadromous salmonids.

E.1 Disturbance Regime and Land Cover

Prior to European settlement, Oregon Cascade Mountain forests were dominated by large conifers (Franklin and Dyrness 1973). Typically, most forests below 3,000 feet are composed of the Western hemlock plant association, primarily of Douglas fir, Western hemlock, and Western red cedar. Younger forests (early seral or successional phase) are dominated by Douglas fir. Western hemlock and Western red cedar develop under the Douglas fir canopy, but do not become the dominant overstory tree for several hundred years (Franklin and Dyrness 1973). Forests above 3,000 feet consist of either the Pacific silver fir or mountain hemlock association, including grand fir, Engelman spruce, and most of the species found in the Western hemlock association.

Upland disturbance regimes in Cascade forests were historically associated with fire, windstorms, insects, and disease. The spatial extent and intensity of these disturbance processes creates patches with different community compositions and physical structures. The disturbances that create new open patches provide a mechanism for secondary succession to occur, wherein early seral species (such as Douglas fir) are followed by mid-seral species, with the stand eventually developing into a complex late seral or old-growth community (Franklin and Dyrness 1973). As discussed in section 5.2.1.2.4, these disturbances not only affect vegetative cover, but in turn affect soil erosion and rates of sediment, large wood, and nutrient delivery to aquatic ecosystems (Wissmar et al. 1994).

At lower elevations in the Willamette basin, vegetation during the pre-development period was dominated by Oregon white oak woodlands, oak savannah, and prairie community types (Johannessen et al. 1970). Many areas of the valley were frequently burned by native Americans to create open habitat that supported game and plants that were staples of their diet (Gregory et al. 2002).

Local vegetation, geology, climate, and upland disturbance regimes produce aquatic systems with channel characteristics, fluvial disturbances, and aquatic biota unique to each subbasin. The composition of upland and riparian plant communities and the disturbance processes necessary to maintain them have been altered since European settlement. European settlement introduced new disturbances, such as timber harvesting, road building, agriculture, and urbanization, which affect existing plant communities and the disturbance processes necessary to maintain properly functioning aquatic habitat.

E.2 Access to Historical Habitat

The viability of a population is linked to spatial structure in several ways. There must be enough high-quality habitat to support reproduction, rearing, and migration, and habitat areas must be connected so that fish can move from one area to the next as their life history requires. Spatial structure also affects viability in more subtle ways:

- Diversity in population structure promotes genetic diversity, a key component of long-term viability
- Depending on the trend in habitat quality at any given time, some areas of current high abundance may actually be population "sinks" (productivity is in decline), while other areas that have fewer spawners may be responsible for most of the production (Pulliam 1988)
- Rates of migration, local extinction, and colonization between areas occupied by a population are typically unknown; thus the actual size of the wild population may be smaller than otherwise assumed (Whitlock and Barton 1997)

As an example of the third point, the spawning aggregation in the mainstem McKenzie River could be in decline but reseeded with strays from the South Fork McKenzie spawning aggregation, or (before all hatchery fish were marked) from the hatchery population.

- In general, the more dispersed the population, the less likely a landslide, volcanic eruption, or similar event will have a catastrophic effect.

E.3 Flow and Hydrology

To the extent practical, the USACE currently operates each of its Willamette Project facilities in conformance with recently established flow guidelines that are developed with the assistance of ODFW for the protection of aquatic resources in downstream river reaches (see Table E-1). These guidelines are somewhat more protective of UWR winter steelhead and spring chinook than the proposed action considered in this biological opinion and constitutes the existing conditions considered in Chapter 4, "Environmental Baseline."

Operations at each Willamette Project dam affect four primary streamflow characteristics, which in turn provide biological requirements of listed fish: peak flows, monthly average flows, minimum flows, and ramping rates. Downstream water withdrawls also affect both streamflow characteristics and anadromous fish habitat and survival. Several of the Willamette project reservoirs store water for out-of-stream use through USBR water service contracts. These streamflow characteristics and their influence on biological requirements are described below.

Table E-1 General Flow Guidelines (Source: USACE (2000), Table 2-1)

	High Flow					Low Flow			Minimum Conservation Pool	Maximum Conservation Pool
	Min	Normal Evacuation Rate	Max Evacuation Rate	Increase per hour	Decrease per hour	Min	Increase	Decrease		
							Increase per hour	Decrease per day		
Hills Creek	300 cfs	6000 cfs	8000 cfs	100-1000cfs : 300cfs 1000-5000cfs : 500cfs 5000-8000cfs : 800cfs Maximum : 1500cfs	4000 per half hour	400 cfs	200 cfs	(1.5'/day tailwater restriction) 1200cfs : 900cfs 1500cfs : 1000cfs 2500cfs : 1500cfs	1448.0	1541.0
							Increase and Decrease			
Dexter	1200 cfs	12000 cfs	15000 cfs	500-1000cfs : 500cfs 1000-4000cfs: 1000cfs 4000-15000cfs: 1500cfs	500-2000cfs : 700cfs 2000-5000cfs : 1500cfs 5000-10000cfs : 2500cfs 10-20 kcfs : 5000cfs	July 1 - Jan 31 1200 cfs Feb 1 - June 30 1200 cfs	Flow per Hr (.3') per Day (.5' tailwater) 1000 300 500 2000 400 700 3000 500 800 4000 600 800 5000 600 900		LOP: 825.0	LOP: 926.0
							Increase per hour	Decrease per hour		
Fall Creek	50 cfs	3800 cfs	4500 cfs	50-1000cfs : 300cfs 1000-4000cfs : 500cfs Maximum : 800 cfs	No Limit	50 cfs May-Aug:150cfs	200 cfs	100 cfs	728.0	830.0
							Increase per hour	Decrease per hour		
Cottage Grove	50 cfs	2500 cfs	3000 cfs	350 cfs	No Limit	Feb-Jun:75cfs Jul-Oct:50cfs Nov-Jan:Inflow	100 cfs per hour 300 cfs max per day	100 cfs	750.0	790.0
							Increase per hour	Decrease per hour		
Dorena	100 cfs	4000 cfs	5000 cfs	100-2000cfs : 500cfs 2000-5000cfs : 750cfs Max per 2hrs : 1500cfs	No Limit	Feb-Jun:190cfs Jul-Oct:100cfs Nov-Jan:Inflow	200 cfs per hour 500 cfs max per day	200 cfs per hour 500 cfs max per day	770.5	832.0
							Increase per hour	Decrease per hour		
Fern Ridge	50 cfs	MNRO = 4650 cfs	MNRO = 6000 cfs	Normal : 750 cfs Maximum : 1000 cfs	No Limit	Feb-Jun:50cfs Jul-Nov:30cfs Dec-Jan:Inflow	200 cfs	200 cfs	353.0	373.5
							Increase per hour	Decrease per hour		
Cougar	100 cfs	5000 cfs	6500 cfs	100-500cfs : 250cfs 500-6500cfs : 500cfs Maximum : 750cfs	500 cfs	300 cfs	200 cfs	200 cfs	1532.0	1690.0
							Increase per hour	Decrease per hour		
Blue River	50 cfs	3000 cfs	3700 cfs	50 - 100cfs : 50 cfs 100-500cfs : 100cfs 500-1000cfs : 200cfs 1000-2000cfs : 400cfs 2000-3700cfs : 600cfs	30%	50 cfs	50-100cfs : 50 cfs 100-500cfs : 100cfs 500-1000cfs : 200cfs 1000-2000cfs : 400cfs 2000-3700cfs : 600cfs	30% (Below 200 cfs 30% per 15 min. - less is better)	1180.0	1350.0
							Increase per hour	Decrease per hour		
Foster	Inflow up to 10000 cfs	12000 - 15000 cfs	18000 cfs	500-1000cfs : 500cfs 1000-3000cfs : 1000cfs 3000-18000cfs : 1500cfs Maximum : 2500cfs	30%	Nov-Jun: 800cfs July: 750cf Aug: 650cfs Sep-Oct: 700cfs	300 cfs	300 cfs	GPR: 922.0 FOS: 613.0	GPR: 1010.0 FOS: 637.0
							Increase and Decrease			
Big Cliff	1000 cfs	10000 cfs	17000 cfs	100-1000cfs : 500cfs 1000-3000cfs : 1000cfs 3000-17000cfs:1500cfs Maximum : 2000cfs		1000 cfs	Flow per Hr (.3') per Day (.5' tailwater) 1000 300 500 2000 400 700 3000 500 900 4000 600 1000 5000 700 1100		DET: 1450.0	DET: 1563.5

Note: Actual project operating criteria may differ. Source: USACE, 2003

- *Frequency of channel-forming and over-bank flows* Natural high flows occur in response to rainstorms and snowmelt runoff. Magnitude (expressed in cubic meters per second [cms] and cubic ft per second [cfs]), frequency (how often a flood of a given magnitude occurs, usually expressed in years), duration (length of the flood event), and seasonal timing are common descriptors of high-flow regimes. Peak flows influence geomorphic and ecological elements of stream channels by transporting and depositing fine and coarse sediments, preventing riparian encroachment and channel narrowing, affecting fish migrations, and maintaining connectivity between channels and floodplains. Floods of certain magnitudes have a geomorphic significance; for example, the bankfull discharge, which has an average recurrence interval of 1.5 to 2 years in many unregulated rivers, is considered the dominant discharge or channel-forming flow in many systems. Higher flows would have a more pronounced effect on channel form but are so infrequent that their effects are generally masked by those of lesser magnitude but higher frequency.

  High flows can influence the behavior and survival of adult and juvenile anadromous salmonids. The timing of adult migration often occurs as high flows decrease, and migration typically ceases during peak high flows. Juveniles seek velocity refuge during winter high flows, potentially a significant source of mortality, and often emigrate during spring high flows. Low-magnitude high flows can provide feeding opportunities for juvenile salmonids.

- *Flow fluctuations* Minimum flows are periodic or seasonal low flows. Minimum flows influence the quality and quantity of stream habitat, determine the amount of wetted stream channel area, and influence temperature and other water quality parameters. Minimum flows can present bottlenecks to population growth by limiting habitat availability (e.g., dewatering spawning and incubation habitat). Low flows can interfere with fish migrations by reducing stream depths at critical riffles (shallows). Low flows can also contribute to adverse water temperature and fish disease effects that can cause rapid and severe die-offs. A ramping event is defined as a natural or human-induced event in which river discharge and water surface elevation increase or decrease. Project operations influence the frequency, magnitude, timing, and rate of ramping events. Ramping rates are typically defined by the rate of change in the stream's water surface elevation (stage), for example, 15 cm/hr (6 in/hr) or 0.3 m/day (1 ft/day). The relationship between change in discharge and change in stage is strongly influenced by cross-sectional channel morphology; confined channels typically experience more rapid stage fluctuations than unconfined channels. Storm events cause natural flow changes, and precipitation and runoff processes in a given watershed influence these rates, but at dams, flows are often ramped in ways that exceed the rate, magnitude, and/or frequency of natural flow changes. In addition to increasing or decreasing stage, flow changes alter the velocity, depth, and shear stress[1] characteristics of rivers, altering physical habitat for aquatic species. Increases in stage (upramping) can displace eggs, juveniles, or adults of aquatic species, increase turbidity as rising water mobilizes sediments, and alter other

[1] "Sheer stress" in this case refers to the force exerted by flowing water on the channel boundaries (floor and walls).

aspects of water quality such as temperature and dissolved oxygen. Decreases in stage (downramping) can move active spawners off gravel bars and can strand eggs or juveniles of aquatic species in shallow pools in dewatered areas of a channel. Frequent and/or rapid ramping can also reduce benthic (bottom-dwelling) species diversity, density, and biomass by reducing the populations of species that are less mobile or less tolerant of dessication and other effects.

- *Seasonal flows* Monthly average flows describe the seasonal hydrograph, the distribution of runoff within a watershed over the course of the year. The characteristics of a stream's seasonal flow pattern strongly affect its suitability as habitat for various aquatic species. For example, migration patterns of locally-adapted anadromous fish often coincide with peaks and valleys in annual streamflow. Changes in these patterns affect a stream's suitability for indigenous anadromous fish, which are highly dependent on the characteristics of the undisturbed hydrologic regime, and can also encourage the growth of non-indigenous populations, which compete with or prey on the indigenous species. Diverting water for out-of-stream water use influences the four streamflow characteristics discussed above. Juvenile fish can become entrained into diversions for out-of-stream use. Water use in the Willamette River basin is administered by the Oregon Water Resources Department (OWRD) through a system of water use permits or water rights based on the prior appropriations doctrine of water allocation. OWRD has defined water availability for over 2,500 streams and stream reaches including several drainages in the Willamette basin. The OWRD determines water availability on a month-by-month basis, allocating water to new water uses until the water needs of the most junior user is satisfied at least 80% of the time. These water availability calculations are useful in identifying when water use conflicts are likely, including conflicts between out-of-stream and instream use (e.g., fisheries needs). The USBR markets water stored in the Willamette Project for irrigation throughout the basin via water service contracts.

E.4 Riparian Vegetation and Floodplain Function

Due to wide variation in physical characteristics, life history strategies, and successional patterns, riparian zones are complex ecological systems (Naiman and Decamps 1997), which can be viewed in terms of patterns of hydrologic and geomorphic processes, terrestrial plant succession, and aquatic ecosystems (Gregory et al. 1991). In addition to reflecting the history of fluvial disturbance from floods, the composition of a specific riparian community reflects the disturbance regimes from the nearby upland areas, including fire, wind disease, and insect outbreaks (Gregory et al. 1991).

Physical processes often provide the setting for a type of riparian communities, but the actual pattern of colonization, establishment, and succession results from interactions between the species and the physical processes (Walker et al. 1986). For example, in unconfined reaches, lateral migration of the stream channel cuts into older plant communities along the outer bend of a meander, mobilizing gravel and fine sediment, which deposit downstream, creating surfaces suitable for colonization by new riparian vegetation (Fonda 1974). Where channel migration is prevalent, riparian plant communities form a heterogeneous mosaic of patches with varying species composition in different successional stages. In alluvial reaches within the Willamette valley, opportunistic, shade-intolerant species, such as black cottonwoods (*Populus trichocarpa*) and various willow species (*Salix spp*.), are often the first woody species to establish new riparian forests, establishing only on bare, moist, open surfaces. As these species mature, shade tolerant species, such as Oregon ash (*Fraxinus latifolia*) and big leaf maple (*Acer macrophyllum*) develop under the canopy of the initial species.

Riparian vegetation in alluvial reaches establishes on bare, open surfaces than can be created by lateral point bar migration (Nanson and Beach 1977), over-bank flooding (Scott et al. 1997), and channel narrowing or avulsion. McBride and Strahan (1984) describe establishment of new cottonwood communities on gravel bars, particularly those associated with large wood accumulations (Abbe and Montgomery 1996). Dykaar and Wigington (2000) report that mid-channel gravel bars are likely the origin for most of the floodplains along the upper Willamette River. Many of the abovementioned landforms are created during high flow events, and these landforms must be created at elevations that are low enough so roots maintain contact with the water table throughout the summer, but high enough to prevent flood damage (Rood and Mahoney 1990) (Nilsson et al. 1991). Due to the complex interaction of these variables affecting survival, willow/cottonwood communities do not establish annually, but rather in 2-10 year intervals that are dependent on channel-shaping events and weather conditions; Mahoney and Rood 1998).

Reducing the magnitude and frequency of peak flows allows vegetation to encroach on and stabilize existing surfaces and prevents the creation of new bars and islands that would be suitable colonization sites for young riparian forests (Ligon et al. 1995).Numerous studies have documented changes in riparian communities in river reaches downstream of dams, and most report a decline in establishment of young riparian forests, which are essential for generation of new floodplain forests and the benefits associated with them (Rood and Mahoney 1990; Rood and Heinze-Milne 1989).

Riparian forests provide many valuable functions to aquatic and terrestrial ecosystems. Riparian vegetation in small streams plays a significant role in controlling primary production within small streams by controlling food sources for macroinvertebrates, which are the food supply for some fish, including juvenile salmonids (Vannote et al. 1980). Riparian forests provide large wood that is necessary for a properly functioning aquatic ecosystem (section E.5). Section E.5 describes how large, key pieces of wood maintain habitat-forming processes in large rivers, illustrating the need for riparian vegetation of appropriate age and size. The successional stage and distance from riparian forest patches to the active channel also controls the amount and intensity of incoming solar radiation into the stream, moderating water temperature, as described in section E.6.

Junk et al. (1989) describe the importance of the exchange of aquatic and terrestrial energy sources during a flood-pulse in a riparian forest, and suggest that the flood-pulse produces and maintains a highly diverse and dynamic habitat structure within floodplains. Vegetated floodplains reduce water velocities during over-bank flows, providing refugia for aquatic organisms, including salmonids, and facilitating deposition of nutrient-rich silt and sediment during high-water events. Floodplains are created and maintained by a dynamic equilibrium involving erosion, transport, and deposition of sediment, and the maintenance of a healthy floodplain forest is dependent of maintenance of these processes.

E.5 Large Wood, Sediment Transport, and Channel Complexity

Upland and riparian vegetation in headwaters and tributaries of the Willamette affect habitat-forming processes involving large wood and sediment. The interaction between properly functioning upland, riparian, large wood, sediment and hydrological processes creates and maintains fish habitat in all sizes of streams.

E.5.1 Role of Upland Vegetation, Land Use, and Disturbance in Habitat-forming Processes

As mentioned in section E.1, a primary upland disturbance affecting aquatic habitat is fire-related input of large wood. High intensity fires consume organic matter that binds the soil together, can reduce the ability of the soil to absorb water, and can increase surface runoff. When combined, these factors can increase the frequency of debris flows that deliver large quantities of sediment into stream channels (Wissmar et al. 1994). Low intensity fires can burn the understory, leaving downed wood available for recruitment into the stream channel, the benefits of which are described in detail in section E.5.3. Fires contributed large wood to stream systems either directly, due to falling burned trees, or indirectly, through the creation of fire-associated landslides that delivered large quantities of large wood. Fire-associated landslides are capable of delivering large quantities of sediment, in unharvested systems, which would be stabilized by the concurrent influx of large wood. Additionally, large wood in the riparian areas frequently burned less intensely, usually leaving enough riparian trees to provide continuous input until the next fire. This influx of sediment and large wood was responsible for patterns of rapid streambed aggradation and slow degradation throughout watersheds that created and maintained quality habitat (Reeves et al. 1995). Fire history studies at the HJ Andrews Experimental Forest in the McKenzie subbasin described historical fire frequency and determined that fire frequency in the study area has increased dramatically since fire suppression began in the early 1910s (Teensma 1987). Fires historically were more frequent, yet episodic in the presettlement era, and varied in extent and intensity, resulting in older-growth stands with multiple age classes, complex structural diversity, multiple-level canopies, and downed wood (BLMS 1997).

While fire frequency has decreased in the Cascades due to fire suppression, a new form of upland disturbance, timber harvesting and associated road building, have dominated the landscape over the latter part of the 20th century. Effects of disturbance due to timber harvesting differ in many ways from those caused by wildfires. While fires and associated landslides introduced both sediment and large wood to streams, timber harvesting usually removes most standing and downed wood. Thus, landslides associated with harvest or roads deliver large quantities of sediment to streams that lack the large wood necessary to retain it (Reeves et al. 1995). Without large wood, sediment is flushed rapidly downstream, often scouring the streambed to bed rock, or resulting in continuous riffle habitat poorly suited for anadromous salmonids. Additionally, wildfires tended to generate large, concentrated areas of disturbance, while timber harvests tend to result in many small, disturbed patches dispersed throughout the landscape. Thus, the spatial pattern of sediment recruitment and the lack of concurrent large wood influx due to timber harvesting do not result in the same habitat-forming processes associated with natural wildfires, and actually degrade salmonid habitat (Reeves et al. 1995). Other land uses can also affect disturbance, habitat processes, and water quality. Many oak savannah, oak woodland, and prairies at lower elevations within the Willamette basin have been converted to agricultural, rural residential, or urban use (Gregory et al. 2002). Areas converted to agriculture were frequently cleared of vegetation and rapidly drained, reducing the amount of water stored within the hillslopes and floodplains and hindering recharge of local groundwater supplies, which provide base flows throughout the low flow season. Waterways adjacent to agriculturally-dominated areas can be contaminated with residues from chemical pesticides and herbicides that are harmful to aquatic biota.

E.5.2 Large Wood and Sediment Input Processes

Large wood can enter streams due to fire-associated landslides (described above), windfall, and natural tree mortality within the riparian area or adjacent hillslope (Grette 1985; Nakamura and Swanson 1993), but tree toppling during natural bank undercutting is the primary input process when the channel migrates across the floodplain in an unconfined reach (Leinkaemper and Swanson 1987; Bilby and Bisson 1998). Larger windthrow events, fires, floods, and landslides can episodically recruit high volumes of large wood and sediment into streams (Keller and Swanson 1979). In steep watersheds, heavy precipitation can trigger hillslope failures, which can enter stream channels and cause massive debris flows. In a debris flow, large quantities of soil, alluvium, large wood and organic material enter the channel and maintain momentum as they rapidly move downstream, gaining mass with increasing amounts of bed material and large wood. While the channel experiencing a debris flow is often scoured down to bedrock, debris flows ultimately deposit the mass of sediment, alluvium, and wood downstream in the channel or at a tributary junction, contributing massive quantities of sediment and large wood to the downstream reaches of the system over a relatively short period of time (Keller and Swanson 1979). Sediment is also supplied to streams through local bank erosion, wherein hydraulic forces scour both the face and the base of the bank, gradually contributing sediment to the system. Excessive scour at the base of the bank can lead to oversteepening and eventual slumping of the bank into the stream channel (Reid and Dunne 2003), delivering more sediment than the initial bank erosion. Toppling of riparian trees into or adjacent to the stream can also introduce sediment.

Large wood is broken down into smaller pieces and transported downstream in high flow events when rising water levels dislodge it from its resting location, or it can be transported episodically from headwater streams and deposited downstream during debris flows. Large wood transported out of headwater and tributary streams serves as source wood for downstream tributaries. However, due to the relatively small size of wood that is transported out of headwaters, the supply must be augmented by local input downstream in order for large wood to function hydraulically in large rivers. Benner and Sedell (1997) describe USACE snag removal efforts along the Willamette River where large wood pieces up to 6 feet in diameter were commonly encountered. Large wood of this size was likely recruited from floodplain forests in alluvial river reaches, rather than transported from headwater streams.

E.5.3 Role of Large Wood and Sediment in Habitat-Forming Processes

Physical habitat within stream and river channels is influenced by complex interactions between sediment supply, transport capability of the river, retention by large wood, and riparian vegetation (Montgomery and Buffington 1998). In small streams, large wood controls the distribution of sediment, bed material, and particulate organic matter in the channel. Large wood impacts streambank stability either by stabilizing the banks through a channel margin (where the bank meets the water) accumulation, or redirecting flow towards channel margins and facilitating streambank erosion (Montgomery and Buffington 1998). In-channel deposits of large wood create both areas of low velocity and shear stress that facilitate sediment deposition, and localized scour that eventually forms pools (Bilby and Bisson 1998). In small, high-gradient streams, large wood forms step-pool sequences that cause deposition upstream of the step and along the margins of the plunge pool downstream of the step (Montgomery and Buffington 1998). Pool spacing is strongly correlated to large wood loading in small to moderate gravel bed channels (Montgomery et al. 1995), and large wood is often associated with small, frequent depositional areas in small streams that become less frequent, but larger as channel size increases (Bilby and Ward 1989). Adequate size and composition of large wood necessary to perform these processes are described by Keller and Swanson (1979) and Bilby and Wasserman (1989).

Farther downstream in a river network, large wood plays a different role in habitat-forming processes. Large wood accumulations and jams are more common than the single trunks commonly found in smaller systems, but channel-spanning jams or accumulations are less common, as large wood accumulations are preferentially deposited on banks, bars, and in secondary channels (Piegay et al. 1999). The increased ability of the channel to transport small pieces of wood out of the system causes the average size of large wood pieces to be greater in larger rivers than in smaller streams (Bilby and Ward 1989). Large, key pieces of wood are necessary to significantly affect local hydraulic forces to create habitat features associated with large wood in larger rivers.

In larger rivers, gravel deposits typically form downstream of large wood accumulations (Keller and Swanson 1979), which can also facilitate creation of pools (Abbe and Montgomery 1996). Large wood jams were associated with 70% of pools observed in a 25 km reach of the relatively pristine Queets River in the Olympic Peninsula in Washington. Those pools associated with large wood tended to be deeper and have greater variance in depth than free-formed pools (Abbe and Montgomery 1996). In addition to creating pool habitat, stable large wood jams create localized sites of sediment aggradation. The aggradation increases the size of the bar and promotes deposition of fine particulate organic material, and the bar eventually becomes colonized by riparian vegetation. Vegetation increases the ability of the bars to accumulate organic matter and fine sediment, facilitating formation of islands and side channels. These vegetated islands can eventually rejoin the floodplain, forming isolated pockets of old-growth floodplain vegetation (Abbe and Montgomery 1996), which can be recruited into the system as key pieces of large wood if the channel migrates into the floodplain. Habitat and floodplain are also formed when high-velocity water (usually during a high flow event) erodes the bank on outside bends of meanders and transports sediment to the inside bend of meanders, where water velocities are slow enough for deposition to occur (Klingeman 1979). Repeated deposition of bed material on the inside of meander bends contributes to floodplain formation (Leopold et al.

1964), and possible stabilization by riparian vegetation. During high flows, sediment can also be deposited in hydraulically-complex areas associated with mid-channel bars, alcoves, side channels (Abbe and Montgomery 1996), and tributary junctions. Where a channel becomes clogged with large wood, the channel can cut directly across the bend, separate the bend from the main flow, and create a horseshoe-shaped, isolated "oxbow lake." As new channels are cut through the floodplain, riparian trees topple into the river and enrich the river with large wood and additional sediment. Most of the channel-shaping processes described above typically occur during high flow events. As described in section E.3, (Flow and Hydrology), Wolman and Miller (1960) identify the flow at which the majority of sediment transport occurs as bankfull discharge, which typically corresponds to a flow with a return interval of 1.5 to 2 years in an unregulated system.

E.5.4 Biological Importance of Channel Complexity Formed by Large Wood and Sediment

The large wood and its geomorphic influences on channels of all sizes have numerous biological impacts. In addition to retention of sediment, the hydraulic complexity caused by large wood facilitates the deposition and retention of particulate organic matter (Naiman and Sedell 1979; Wallace et al. 1995; Bilby and Likens 1980) and even salmon carcasses (Cederholm et al. 1989). Retention of particulate organic matter is necessary for adequate conversion of coarse particulate organic matter by shredder macroinvertebrates into finer particles to be consumed by collector/gatherer macroinvertebrates (Merritt and Cummins 1975). Macroinvertebrates serve as a food source for rearing salmonids that feed in the water column or at the surface on drifting food (Mundi 1969; Chapman and Bjornn 1969). Additionally, pools formed by large wood provide a location where fish can maintain their position with a minimal expenditure of energy to obtain food carried by the current (Fausch 1984). Numerous studies have documented the use of large wood-related habitat by juvenile salmonids. Shirvell (1990) found that 83% of steelhead parr and 99% of juvenile coho were associated with root wads placed in mid-channel areas where previously cover had been sparse, and Sedell et al. (1984) determined that complex wood structures, such as root wads or accumulations, tended to attract more fish than single logs.

Complex networks of gravel bars, side channels, and islands formed by large wood and sediment transport in alluvial reaches provide complex habitat useful to salmonids in many life stages. Large wood accumulations in large channels form pool habitat useful as holding habitat for adult salmon, facilitate spawning gravel deposition, and create areas of slow-water refugia during high flow events. Alcoves and side channels are utilized for refuge and feeding areas by rearing salmonids (Landers et al. 2002). Lateral channel migration, large wood accumulations, and mid-channel bar formations also increase erosion and subsequent deposition of gravel necessary for spawning. The formation and maintenance of a complex network of side channels in unconfined streams and rivers also benefits the aquatic ecosystem by providing increased opportunities for floodplain inundation (assuming ample flood flows), providing increased off-channel habitat for rearing and spawning and opportunities for energy and nutrient exchange between the river and floodplain.

The repeated transport and deposition of gravel and cobble is critical in maintaining connections between surface water and hyporheic water, which flows within the gravel and material beneath a river. Water flowing hyporheically experiences many changes, including a significant reduction in temperature. In the Willamette River between Harrisburg and Corvallis, a volume equal to approximately 70% of the surface volume of the Willamette flows hyporheically (Enright et al. 2002, Landers et al. 2002). On hot summer days, water in the head of alcoves in the Willamette, consisting of water resurfacing from hyporheic flow, was between 3.6 and 9.0 degrees F (2.0 and 5.0 degrees C) cooler than water in the main channel of the Willamette (Enright et al. 2002, Landers et al. 2002). Thus, the formation of new gravel bars through which water can flow hyporheically is critical to maintaining appropriate water temperatures within gravel-bed rivers.

Maintenance of proper sediment and large wood processes is inherently linked to processes associated with riparian and floodplain vegetation, as well as hydrologic function and processes described in sections E.3 and E.4. When these processes function in concert, they provide habitat for salmonids at all life stages in all sizes of streams within the watershed network.

E.5.5 General Effects of Dams on Channel Complexity

As described above, aquatic habitat is created and maintained by a balance between sediment and large wood retention and transport. This balance depends on adequate sources of sediment and large wood, sufficient storage mechanisms, and flows necessary to mobilize particles downstream. In reaches downstream of flood control dams, the river is no longer supplied with sediment and large wood from upstream areas, and the frequency of peak flows capable of moving large bed material decreases. When fine bed material is transported downstream without being replenished from upstream, the channel bed coarsens (the materials are coarser) and downcuts (is cut lower) so that the bed material is larger and more stable than in the pre-dam condition (Williams and Wolman 1984). In braided river reaches, the river stabilizes and narrows due to an encroachment of riparian vegetation, and in meandering sections of the river, meandering rates decrease (Friedman et al. 1998). Channelization and revetments further prevent lateral migration of the channel and decrease the ability of the river to recruit sediment from its banks and the floodplain. The result is a straightened and simplified river, which lacks the hydraulic complexity to deposit and retain sediment. This increases the river's capacity to continue transporting bed material out of the system, which can result in further downcutting. A decrease in large wood due to blocked upstream input or lack of recruitment from floodplain forests further prevents the channel from storing what fine material, such as gravel, remains in the system (Williams and Wolman 1984).

E.6 Water Quality

E.6.1 Temperature

Salmonids are ectothermic (cold-blooded) and experience adverse effects, including mortality, when exposed to temperatures outside a relatively narrow optimal range.[2] Logging, farming,

[2] Although historical summer water temperatures probably exceeded optimal conditions on some rivers at times, the natural temporal and spatial diversity of habitat probably provided enough cold water during summer to allow salmonid populations to thrive.

mining, hydropower development, and other activities have altered the natural thermal characteristics of rivers and streams in the Pacific Northwest in the following ways (McCullough et al. 2001; Sauter et al. 2001):

- Increasing summer maximum temperatures; interfering with migrations, feeding, growth, reproductive success, competitive ability, physiological condition (including disease resistance), and predator avoidance
- Reducing or eliminating cold-water refugia, which provide protection from maximum summer temperatures and the habitat diversity needed for behavioral thermoregulation
- Changing the natural seasonal temperature patterns (seasonal thermograph) of rivers and streams, disrupting the adaptive life history strategies of salmonid populations

The EPA has recently recommended numerical water temperature criteria for each salmon and steelhead life stage that occurs during summer maximum temperature conditions. These considerations are based on the information summarized in Table E-1. NOAA Fisheries focuses on summer conditions because actions that achieve these goals would also be likely to reduce temperatures throughout the summer and during late spring and early fall. NOAA Fisheries also presents temperature maxima for salmonid uses that occur outside the summer period such as spawning, egg incubation, and steelhead smoltification (i.e., during spring through early summer or late summer through fall; Tables E-2 and E-3).

Not all temperature problems are related to overly warm temperatures. Unseasonably cool water released from Willamette Project reservoirs during late spring and summer is thought to block or delay the migration of adult salmonids into the mid- to upper reaches of some tributaries. According to USACE (1995b), discussions with resource agencies and previous studies have identified 52 degrees F (11 degrees C) as the optimal temperature that prompts spring chinook and steelhead to move upstream. Anadromous salmonids do not feed during their spawning migration and must rely on stored energy reserves. Prolonged delay can deplete these reserves to the degree that fish die before spawning.

The change in the seasonal thermograph is due to stratification, a phenomenon that occurs in most mid-latitude lakes. Due mainly to increased solar radiation, a warmer, less dense layer of water forms near the surface of lakes and reservoirs and a cold, more dense layer forms below the upper layer. The upper layer is called the epilimnion; the lower layer is termed the hypolimnion. Stratification typically begins in April and subsides by November. Because water is withdrawn from near the bottom of the reservoirs, water released from the project during the stratified period is typically colder than pre-project water temperatures. Water discharged in autumn is typically warmer than pre-project temperatures because, when the reservoir drawdown for flood damage reduction season, warmer epilimnotic waters are discharged. Stratification may be insignificant in very shallow lakes and reservoirs where wind mixes the water nearly to the bottom.

McCullough et al. (2001) and Sauter et al. (2001) discuss the following effects of temperature on the physiology and behavior of Pacific Northwest salmonids:

- Within an acceptable range, incubating eggs develop faster at higher temperatures, shortening the time to emergence. A thermal regime that cools rapidly from 53.6 degrees F (12 degrees C) and achieves low winter temperatures (according to natural cooling processes and rates) is essential for acquiring the necessary thermal units to ensure proper emergence timing and high egg survival.
- Feeding rates and growth rates can increase with temperature assuming that food is not limiting and water temperatures do not exceed the range for feeding. At temperatures above that range, feeding (and growth) rates can decrease. If growth rates are too low during the summer rearing period, body fat is not sufficient to sustain a fish during the winter rearing period. Optimum growth during the warm, maximum growth season (generally summer) is linked with high survival.
- Larvae and juveniles are generally attracted to warmer temperatures for feeding and growth than are larger juveniles or adult fish. The higher thermal preferences of young-of-the-year salmonids may attract them to warmer downstream temperatures, improving growth early in the season. However, as seasonal temperatures increase and the thermal preferences of these juveniles decrease, these fish may not be capable of moving upstream into cooler reaches.
- Water temperature controls the timing and duration of smoltification by controlling the rates of biochemical and physiological processes. High water temperatures inhibit the gill ATPase osmoregulatory enzyme, leading to the loss of migratory behavior.
- Adult salmonids reduce the energetic cost of over-summering in freshwater before spawning by holding in cold-water refugia, typically deep pools, which may be selected early in the season based on non-thermal cues such as groundwater flow. If water temperature is high (or oxygen concentrations are low) and there are no refugia, swimming speed can be impaired and fish may refuse to migrate or migrate back downstream.
- Adult salmonids with summer and fall spawning migrations are most likely to be exposed to high water temperatures outside their optimal range. Prolonged exposure to elevated temperatures can reduce the viability of gametes and is significantly related to prespawning mortality.
- The timing of spawning is genetically controlled and local stocks are probably adapted to temperatures that enhance their survival and reproductive success.
- Spawning temperatures may reflect the optimal physiological temperatures for incubation and egg development rather than the preferred temperatures of spawning adults.

Table E-2. Summary of temperature considerations for salmon and steelhead life stages. These parameters were developed with the assistance of the Services, the Northwest states, and the member Tribes of the Columbia River Inter-tribal Fish Commission. (Source: EPA 2003a)

Life Stage	Temperature Consideration	Temperature (Unit)	Reference
Spawning and Egg Incubation	• Temp. Range at which Spawning is Most Frequently Observed in the Field	39-57 degrees F(4-14°C) daily avg	Sauter et al. (2001); pp 17-18 McCullough et al. (2001); p 81
	• Egg Incubation Studies - Results in Good Survival	39-54 degrees F (4-12°C) constant	McCullough et al. (2001); p 16
	- Optimal Range	43-50 degrees F (6-10°C) constant	
	• Reduced Viability of Gametes in Holding Adults	>55°F (>13°C) constant	McCullough et al. (2001); pp 16 and 75
Juvenile Rearing	• Lethal Temp. (1 Week Exposure)	73-79 degrees F(23-26°C) constant	McCullough et al. (2001); pp 12, 14 (Table 4), 17, and 83-84
	• Optimal Growth - unlimited food	55-68 degrees F (13-20°C) constant	McCullough et al. (2001); pp 3-6 (Table 1), and 38-56
	- limited food	50-61 degrees F (10-16°C) constant	
	• Rearing Preference Temp. in Lab and Field Studies	50-63 degrees F (10-17°C) constant <64 degrees F (<18°C) 7DADM	Sauter et al. (2001); p. 4 (Table 2). Welsh et al. 2001.
	• Impairment to Smoltification	54-59 degrees F (12-15°C) constant	McCullough et al. (2001); pp 7 and 57-65 McCullough et al. (2001); pp 7 and 57-65
	• Impairment to Steelhead Smoltification	>54°F (>12°C) constant	
	• Disease Risk (lab studies) - High	>64-68°F (>18-20°C) constant	Materna (2001), pp 12 - 23
	- Elevated	57-63°F (14-17°C) constant	
	- Minimized	54-55°F (12-13°C) constant	
Adult Migration	• Lethal Temp. (1 Week Exposure)	70-72°F (21-22 degrees C) constant	McCullough et al. (2001); pp 17, 83 - 87

Life Stage	Temperature Consideration	Temperature (Unit)	Reference
	• Migration Blockage and Migration Delay	70-72°F (21-22 degrees C) average	McCullough et al. (2001); pp 9, 10, 72-74. Sauter et al. (2001); pp 15 - 16
	• Disease Risk (lab studies)		Materna (2001); pp 12 - 23
	- High	>64-68 degrees F (>18-20°C) constant	
	- Elevated	57-63 degrees F (14-17°C) constant	
	- Minimized	54-55 degrees F (12-13°C) constant	
	• Adult Swimming Performance		McCullough et al. (2001); pp 8, 9, 13, 65 - 71
	- Reduced	> 68 degrees F (> 20°C) constant	
	- Optimal	54- 66 degrees F (15-19°C) constant	
	• Overall Reduction in Migration Fitness due to Cumulative Stresses	>63-64 degrees F (>17-18°C) prolonged exposures	McCullough et al. (2001); p 74

Table E-3. Temperature criteria for salmonid uses during the summer maximum period. (Source: EPA 2003a)

Salmonid Uses During Summer Maximum Temperature Conditions	Recommended Maxima
Salmon/steelhead "core" juvenile rearing[1]	61 degrees F (16°C) 7DADM[2]
Salmon/steelhead juvenile migration plus non-core rearing[3]	64°F (18°C) 7DADM
Salmon/steelhead migration[4] .	68°F (20°C) 7DADM with a provision to take all feasible steps to protect and restore the natural thermal regime

[1] In general, "core" juvenile rearing areas are defined as the moderate to high density summertime salmonid rearing areas in the mid-to-upper reaches in Northwest river basins (downstream from areas used by juvenile bull trout). However, EPA (2003a) suggests that in colder climates, such as the west slopes of the Cascades, it may be appropriate to apply this criterion all the way to the estuary. This criterion can also be applied to adult holding prior to spawning.

[2] 7DADM = 7-day average of the daily maxima. EPA (2003a) recommends this metric because it describes the maximum temperatures in a stream but is not overly influenced by the maximum temperature of a single day. It can be used to protect against acute effects such as lethality and migration blockages, and against sub-lethal or chronic effects.

[3] "Non-core" juvenile rearing areas are defined as moderate to low density summertime salmonid rearing areas, generally found in the mid- to lower basin, downstream of the core juvenile rearing areas. By setting this use designation, EPA (2003a) recognized that salmonid juveniles will use areas outside of their optimal thermal range.

[4] EPA (2003a) recommends this use for waterbodies that are used almost exclusively for migrating salmonids during the period of summer maximum temperatures (i.e., in the lower part of river basins where, based on the best available scientific information, natural background maximum temperatures probably reached 68C (20 degrees C).

Table E-4. Temperature criteria for salmonid uses that occur outside the summer maximum period. (Source: EPA 2003a)

Other Salmonid Uses	Recommended Maxima
Salmon/steelhead spawning, egg incubation, and fry emergence[1]	55 degrees F (13 degrees C) 7DADM
Steelhead smoltification[2]	57 degrees F (14 degrees C) 7DADM

[1] Generally, this use occurs in late summer-fall for spring chinook and in spring-early summer for steelhead.

[2] Generally, steelhead begin to smolt in April and May as yearling fish make their way to the ocean. Steelhead smoltification can be impaired from exposure to greater than 54CF (12 degrees C) constant temperatures. Fish may cease migration or may migrate to the ocean undeveloped, thereby reducing their estuary and ocean survival.

E.6.2 Dissolved Oxygen

Adult salmonids require adequate concentrations of dissolved oxygen (DO) to sustain the high energy expenditure required for upstream swimming. Reductions in DO can decrease swimming performance in both adult and juvenile fish, affecting the ability to migrate, forage, and avoid predators (ODEQ 1995; Spence et al. 1996). Thus, any reduction in DO below saturation increases the risk of adverse sublethal or lethal effects. For many fish species, embryonic and larval stages often require the highest DO concentrations; as DO decreases, the time to hatching increases, and growth and survival decrease. Low DO concentrations increase the acute toxicity of various toxicants (toxic materials) such as metals (e.g., zinc) and ammonia (ODEQ 1995). At low intergravel DO (IGDO) and water velocity, ammonia exposure can adversely affect eggs in redds. Adverse effects of toxicants can be compounded by low DO. Also, toxicants can increase sensitivity to low concentrations of DO. For example, any toxicant that damages the gill epithelium can decrease the efficiency of oxygen uptake.

Productive streams exhibit diurnal cycles in water-column DO concentrations due to photosynthesis and respiration. Although fish can detect and attempt to avoid areas of low DO, the damage that can occur during diurnal minima depends on the length and frequency of exposure.

The Oregon Department of Environmental Quality (ODEQ) established a cold water DO standard for salmonid spawning and incubation of 11 mg/L as a 7-day average minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0 mg/L criterion, DO levels must not be less than 95% saturation. The ODEQ also established an absolute minimum DO standard for waters supporting cold water aquatic life of 8.0 mg/L (or 90% saturation). NMFS (1999g) evaluated the U.S. Environmental Protection Agency's (EPA) proposal to approve these standards and concluded that the cold-water DO standard was likely to adversely affect both UWR chinook salmon and steelhead because it would apply in migratory corridors or in habitat used for both rearing and migration. However, NMFS concluded that take associated with approval of the DO standard was not likely to be of a magnitude or duration that would appreciably diminish the likelihood of survival and recovery of either species.

E.6.3 Total Dissolved Gas

Dam operations that create falling water (e.g., regulating outlet spill) can entrain volumes of air. As the water plunges, the hydrostatic pressure at depth forces entrained gases into solution, causing supersaturation of total dissolved gas (TDG). Supersaturated TDG conditions can persist for some distance below a dam before the gases dissipate at the air/water interface (e.g., the river surface, wave action on the surface, or air bubbles from rapids and riffles), and TDG in excess of 110% saturation can produce hazardous conditions for aquatic organisms. Fish absorb gas into the bloodstream during respiration, which passes from the dissolved state into the gaseous phase as internal bubbles or blisters. Susceptibility to this condition, called gas bubble trauma, is highest near the surface, where the reduced hydrostatic pressure allows the gas to come out of solution. The ODEQ water quality standards require that the concentration of TDG relative to atmospheric pressure at the point of sample collection not exceed 110% of saturation, except when stream flow exceeds the ten-year, seven-day average flood (OAR 340-041-0031;

ODEQ 2008). However, depth exerts additional pressure that increases the solubility of dissolved gases in the bloodstream, sufficiently to compensate for approximately 10% of saturation. Therefore, a total gas pressure of 120% of saturation at the surface is actually on 110% at 1 m and 100% at 2 m (Weitkamp and Katz 1980).

Chinook salmon are particularly vulnerable to gas bubble disease during the yolk sac fry stage. Once the yolk is fully absorbed and the body cavity has “buttoned up,” fry are generally very tolerant to high dissolved gas concentrations. Typically, chinook salmon fry are in the yolk sac stage during late February through April, although incubation and emergence probably occur earlier in the mainstem tributaries immediately below the USACE dams. Weitkamp and Katz (1980) review the dissolved gas supersaturation literature and describe the following signs of gas bubble disease in chinook salmon larvae and fry:

- Bubbles formed between the yolk sac and the perivitelline membrane, causing fry to swim head up. As the bubbles expanded and moved posteriorly, the fry swam tail up and eventually belly up. Death occurred when the vitelline membrane ruptured (combined observations of Embody 1934, Wood 1968, Rucker and Kangas 1974, and Stroud et al. 1975, described in Weitkamp and Katz 1980).
- Large gas bubbles formed in the posterior portion of the yolk sac of chinook salmon sac fry. Dead fish had frayed fins and coagulated yolks (Zirges and Curtis 1975, cited in Weitkamp and Katz 1980).

The compensation depth described above applies to eggs and fry in the redds, as well as fish swimming in the water column. Depth compensation is equal to 10% reduction in TDG for each meter of water depth so, if TDG measured in the water over the highest redds is 115%, there must be at least one meter of water covering the redds to give an effective TDG of 105% at the redd level. The ODEQ water quality standards require that TDG in hatchery receiving waters and waters less than two feet deep not exceed 105% of saturation (OAR 340-041-0031; ODEQ 2008).

E.6.4 Nutrients

Phosphorus, carbon, and nitrogen are primary nutrients required by plants and animals to make tissue. Given adequate levels of light, temperature, and water, these nutrients control the amount of primary production in an ecosystem, which in turn determines the productivity of invertebrates and vertebrates. Small streams in many forested watersheds of the upper Willamette basin typically have very low concentrations of nitrogen, which is therefore the limiting nutrient (Triska et al. 1984). Anadromous salmonids are an important source of nitrogen to watersheds across their ranges, especially in the volcanic geologies of the Cascade Mountains (Cederholm et al. 1999; Gresh et al. 2000). This marine-derived nitrogen is heavily used by terrestrial plants and animals as well as aquatic organisms (Bilby et al. 1996; Willson et al. 1998; Hilderbrand et al. 1999).

In the lower elevations of the Willamette Valley, farmers apply nutrients such as phosphorus, nitrogen, and potassium in the form of fertilizers, manure, sludge, irrigation water, legumes, and crop residues to the soil to enhance production. Nutrients applied in excess of plant needs can wash into aquatic ecosystems and cause excessive plant growth. At extreme levels, aquatic plant growth can increase the biological oxygen demand enough to create a hypoxic condition that kills fish (EPA 2003a).

E.6.5 Turbidity

Turbidity describes the amount of suspended and dissolved matter in a water body, measured as the amount of light intercepted by these particles. Turbidity is affected by water velocity and therefore is measured *in situ*, but once a water sample is collected, the suspended and dissolved fractions can be separated by a standardized filtration process (with the dissolved portion passing through the filter). Both turbidity, due to the effect it has on light penetration through the water column, and suspended sediment affect fish condition, and the effects reported in the literature as range from beneficial to detrimental. However, elevated suspended solids have been reported to enhance cover, reduce rates of predation by piscivorous fishes and birds Gregory and Levings (1998), and improve survival. Elevated suspended solids can also cause physiological stress, reducing growth and adversely affecting survival. Newly emerged salmonid fry may be more vulnerable to the effects of even moderate levels of turbidity than are older fish (Bjornn and Reiser 1991). Where velocity slows and fine materials settle out of the water column into the redds, they can reduce incubation success (Bell 1991). Other behavioral effects on fish, such as gill flaring and feeding changes, have been observed in response to pulses of suspended sediment (Berg and Northcote 1985).

The actual effects depend on the season, frequency, and duration of the exposure, as well as the suspended solids concentration or turbidity. Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991). However, other research demonstrates that feeding and territorial behavior can be disrupted by even short-term exposure to turbid water, and chronic exposure can cause physiological stress responses that increase the expenditure of maintenance energy and reduce feeding and growth (Lloyd 1987; Redding et al. 1987; Servizi and Martens 1991).

Behavioral avoidance may be one of the most important effects of suspended sediments (DeVore et al. 1980; Birtwell et al. 1984; Scannell 1988). Salmonids have been observed to move laterally and downstream to avoid turbid plumes (McLeay et al. 1984; Sigler et al. 1984; Lloyd 1987; Scannell 1988; Servizi and Martens 1991). Juvenile salmonids tend to avoid streams that are chronically turbid, such as glacial streams or those disturbed by human activities, except when the fish need to traverse these streams along migration routes (Lloyd et al. 1987).

In systems with intense predation pressure, enhanced survival due to protection from predators may balance any physiological effects such as reduced growth. Gregory (1993) reported that turbidity levels of about 23 Nephelometric Turbidity Units (NTU) minimize predation risk.

E.6.6 Toxics

A toxic substance is one that has the potential to cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformities in organisms or their offspring (NCSU 2008). Organisms are exposed to toxicants either directly in the environment or indirectly by ingestion through food chains. In aquatic systems, toxic substances are generally grouped into metals and organic compounds, including pesticides. Metals and toxic organic substances have entered waterways through point source discharges, although permissible discharges of these materials are now regulated under the Federal Clean Water Act of 1972 (as amended in 1977).

The EPA's National Water Quality Inventory reported that agricultural nonpoint source pollution was the leading source of water quality impacts to surveyed rivers and lakes nationwide, the third largest source of impairment to surveyed estuaries, and a major contributor to ground water contamination and wetlands degradation (EPA 2003b). Agricultural activities that cause nonpoint source pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting. The major toxic pollutants that result from these activities are chemical pesticides, including organophosphates (carbamates, organochlorine insecticides, and pyrethroids) (EPA 2003 c)