United States Department of Commerce
United States Department of the Interior

National Marine Fisheries Service
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U.S. Fish and Wildlife Service
1936 California Avenue
Klamath Falls, OR 97603

NMFS: SWR-2012-9372

FWS: 08EKLA00-2013-F-0014

MAY 31 2013

Mr. Jason Phillips
Area Manager
Bureau of Reclamation
6600 Washburn Way
Klamath Falls, Oregon 97603

Dear Mr. Phillips:

Thank you for your December 1, 2012, letters requesting initiation of formal consultation with NOAA's National Marine Fisheries Service (NMFS) and the U. S. Fish and Wildlife Service (USFWS; collectively the Services) pursuant to section 7(a)(2) of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq.*). During the consultation period, NMFS received two letters from the Bureau of Reclamation (Reclamation) clarifying its proposed action on December 21, 2012, and May 29, 2013. The USFWS also received a letter from Reclamation clarifying its proposed action on May 3, 2013. This letter transmits the Services' integrated biological opinion for Reclamation's proposed operation of the Klamath Project from May 31, 2013, through March 31, 2023.

The enclosed integrated biological opinion describes the Services' analysis of the effect of Reclamation's implementation of the proposed operations of the Klamath Project through March 31, 2023, on the threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), threatened southern DPS of Pacific eulachon (*Thaleichthys pacificus*), threatened Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) evolutionarily significant unit (ESU), endangered Lost River sucker (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), and designated critical habitat for the southern DPS of Pacific eulachon, SONCC coho salmon ESU, Lost River sucker, and shortnose sucker in accordance with section 7(a)(2) of the ESA.

NMFS concurs with Reclamation that the project, as proposed, is not likely to adversely affect the southern DPS of North American green sturgeon, the southern DPS of Pacific eulachon, and critical habitat for the southern DPS of Pacific eulachon. Based on the best available scientific and commercial information, the Services conclude that the action, as proposed, is not likely to jeopardize the continued existence of the SONCC coho salmon ESU, Lost River sucker, and shortnose sucker; and is not likely to result in the destruction or adverse modification of critical habitat for the SONCC coho salmon ESU, Lost River sucker, and shortnose sucker. However, the Services expect incidental take of SONCC coho salmon, Lost River sucker, and shortnose sucker, as well as adverse effects to designated critical habitat for SONCC coho salmon, Lost River sucker, and shortnose sucker, as a result of implementation of the proposed action.

The Services appreciate Reclamation's close coordination and collaboration throughout the development of the proposed action and consultation period. We look forward to providing appropriate assistance during Reclamation's implementation of its new and innovative water management approach that should better optimize limited water supplies to benefit listed fish and farmers. If you have any questions regarding this biological opinion, please contact Ms. Irma Lagomarsino of NMFS at (707) 825-5160 or Ms. Laurie Sada of USFWS at (541) 885-2507.

Sincerely,

Kevin Chu

Laurie R Sada

for William W. Stelle, Jr.
Acting Regional Administrator
NMFS Southwest Region

Laurie R. Sada
Field Supervisor
Klamath Falls Fish and Wildlife Office

Enclosure

cc: w/enclosure
Ren Lohoefener, USFWS, Southwest Pacific Region
Irma Lagomarsino, NMFS, Southwest Region
NMFS administrative file 151422SWR2011AR001315

National Marine Fisheries Service
United States Fish and Wildlife Service

Biological Opinions

on the

Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species

Prepared By:

National Marine Fisheries Service
Southwest Region
Northern California Office

and

U.S. Fish and Wildlife Service
Pacific Southwest Region
Klamath Falls Fish and Wildlife Office

May 2013

NMFS file number: SWR-2012-9372
FWS file number: 08EKLA00-2013-F-0014

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ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Definition
ac	acres
af	acre-feet
AFA	*Aphanizomenon flos-aquae*
BA	biological assessment
BiOp	biological opinion
BOD	biological oxygen demand
^{o}C	degrees Celsius
CDFG	California Department of Fish and Game (now CA Department of Fish and Wildlife)
CDFW	California Department of Fish and Wildlife
CEPA	California Environmental Protection Agency
cfs	cubic feet per second
cm	centimeters
CWT	coded wire tag
DO	dissolved oxygen
DPS	distinct population segment
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
ET	evapotranspiration
EWA	environmental water account
^{o}F	degrees Fahrenheit
FASTA	Flow Account Scheduling Technical Advisory
FERC	Federal Energy Regulatory Commission
FES	fish evaluation station
FR	Federal Register
ft	feet
ha	hectares
HUC	hydrological unit area
Ich	*Ichthyophthirius*
IGD	Iron Gate Dam
IGH	Iron Gate Hatchery
IP-km	intrinsic potential-kilometer
in	inches
kaf	1,000 acre-feet
KBPM	Klamath Basin Planning Model
KBRA	Klamath Basin Restoration Agreement
Kg	kilogram
KBRT	Klamath Basin Rangeland Trust
KHP	Klamath Hydroelectric Project
KHSA	Klamath Hydroelectric Settlement Agreement

Abbreviation/Acronym	Definition
KLS	Klamath largescale suckers
km	kilometers
LRS	Lost River sucker
m	meters
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MDN	marine-derived nutrients
mi	miles
mg	milligrams
mg/L	milligrams per liter
mm	millimeters
mtDNA	mitochondrial DNA
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
O&M	operation and maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PCE	primary constituent elements
PFMC	Pacific Fishery Management Council
PIT	passive integrated transponder
POR	period of record
Project	Klamath Project
proposed action	proposed operation of the Klamath Project from May 31 2013 through March 31, 2023
Reclamation	Bureau of Reclamation
RM	river miles
RPA	reasonable and prudent alternative
RPM	reasonable and prudent measure
Services	U.S. Fish and Wildlife Service and National Marine Fisheries Service
SNS	shortnose sucker
SONCC	Southern Oregon/Northern California Coast
T&C	Terms and Conditions
TMDL	total maximum daily load
UKL	Upper Klamath Lake
USBR	U.S. Bureau of Reclamation
USDOI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	viable salmonid population

Abbreviation/Acronym	Definition
YTEP	Yurok Tribal Environmental Program
WDFW	Washington Department of Fish and Wildlife
WRIMS	Water Resource Integrated Modeling System
WUA	weighted usable area
Yr	year

1 INTRODUCTION

This document transmits the concurrence determinations and biological opinions (BiOp) of the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS; collectively, the "Services" or "we"), based on our review of the proposed operations of the Klamath Project (Project) by the Bureau of Reclamation (Reclamation) in Klamath County in Oregon and Siskiyou and Modoc Counties in California. Table 1.1 displays the Federally-listed species (hereafter referred to as listed species) and critical habitats considered in this document.

This document was prepared in accordance with section 7 of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. § 1531 et seq.). Reclamation's request for formal consultation was received by the USFWS and the NMFS on December 3, 2012.

Table 1.1. Listed species and critical habitats considered in this document.

Scientific name	Common name	Listing	Critical habitat
Chasmistes brevirostris	shortnose sucker (SNS)	Endangered	Yes
Deltistes luxatus	Lost River sucker (LRS)	Endangered	Yes
Acipenser medirostris	Southern Distinct Population Segment (DPS) green sturgeon	Threatened	No
Oncorhynchus kisutch	Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU)	Threatened	Yes
Thaleichthys pacificus	Southern DPS eulachon	Threatened	Yes

This BiOp and the concurrence determinations are based on information provided in Reclamation's Final Biological Assessment (BA; Reclamation 2012) and other sources of information. A complete record of this consultation is on file at the NMFS Northern California office in Arcata, California, and at the USFWS office in Klamath Falls, Oregon.

2 BACKGROUND AND CONSULTATION HISTORY

2.1 Background

The Klamath Basin's hydrologic system currently consists of a complex of interconnected rivers, canals, lakes, marshes, dams, diversions, wildlife refuges, and wilderness areas. Alterations to the natural hydrologic system began in the late 1800s and expanded in the early 1900s, including water diversions by private water users, Reclamation's Project, and several hydroelectric dams operated by a private company, currently known as PacifiCorp. PacifiCorp's Klamath Hydroelectric Project (KHP) was constructed between 1911 and 1962, and includes eight developments: (1) East and (2) West Side power facilities at Link River Dam; (3) Keno Dam; (4) J.C. Boyle Dam; (5) Copco 1 Dam; (6) Copco 2 Dam; (7) Fall Creek Dam; and (8) Iron Gate Dam (IGD). The Link River Dam and Upper Klamath Lake (UKL) are not part of the KHP. PacifiCorp operated the KHP under a 50-year license issued by the Federal Energy Regulatory Commission (FERC) until the license expired in 2006. PacifiCorp continues to operate the KHP under annual licenses based on the terms of the previous license.

In 2001, the Services issued BiOps on the effects of Reclamation's Project operations on listed species, and concluded that the proposed Project operations would likely jeopardize the continued existence of the Lost River sucker (LRS) and the shortnose sucker (SNS) in UKL (USFWS 2001) and the Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU) (NMFS 2001a). Because of a severe drought in 2001 and the jeopardy BiOps, Reclamation limited the volume of water delivered to Project agricultural users, and to the Lower Klamath and Tule Lake National Wildlife Refuges.

In early 2002, the National Research Council (NRC) concluded that "all components of the BiOp issued by the USFWS on the endangered suckers have substantial scientific support except for the recommendations concerning minimum water levels for Upper Klamath Lake." The NRC (2002a) "found a sound scientific basis for recommendations in the NMFS 2001 BiOp involving coordination of operations and reduction of ramping rates for flows below the mainstem dams." However, the NRC found little scientific support for minimum mainstem flows to maintain and recover coho salmon populations. Nevertheless, the NRC did not conclude that NMFS must be wrong in its recommendations on mainstem flows that were included in the NMFS 2001 BiOp as a reasonable and prudent alternative (RPA; NRC 2002b). The NRC (2002a, 2004) also noted that Reclamation's proposed lake and river flows, which would have caused lower mean lake levels or lower minimum river flows, lacked scientific justification.

In March 2002, one month after the NRC issued its Interim Report (NRC 2002a), Reclamation finalized a new BA that covered Project operations from May 31, 2002, to March 31, 2012, and requested consultation with the NMFS and the USFWS. The USFWS issued a BiOp (finalized in May 2002) that Reclamation's implementation of this new proposal was likely to jeopardize the continued existence of the LRS and the SNS, and provided an RPA that involved application of an adaptive management approach that still allowed for Project water deliveries. NMFS finalized a BiOp on May 31, 2002, and concluded that Reclamation's proposed operations would likely jeopardize the continued existence of the SONCC coho salmon and would likely adversely modify critical habitat of SONCC coho salmon. In coordination with Reclamation, the NMFS' BiOp also included a RPA that consisted of Reclamation operating the Project to ensure that IGD minimum flows increased gradually over three phases during the 10-year period of the plan for Project operations, among other additional requirements. Reclamation provided full water deliveries to irrigators in 2002 despite the continued drought.

In September 2002, at least 33,000 adult salmonids died in the lowermost 40 miles of the mainstem Klamath River (CDFG 2004a, Guillen 2003, NRC 2004, Yurok Tribal Fisheries Program 2004). The fish kill was unprecedented and affected primarily Chinook salmon, although coho salmon (approximately 344), steelhead, and green sturgeon also died. The immediate cause of mortality was massive infections of *Ichthyopthirius multifilis* (ich) and the bacterial pathogen *Flavobacter columnare* (columnaris; CDFG 2003, Guillen 2004a, NRC 2004, Yurok Tribal Fisheries Program 2004).

Several fisheries groups, environmental organizations, and tribes filed suit against Reclamation and the NMFS in Federal district court, alleging violations of the ESA. The district court overturned a significant aspect of the RPA, finding the requirement that Reclamation provide only 57 percent of the long-term flows to be arbitrary and capricious. The issue on appeal was the district court's determination that Phases I and II of the RPA, or the short term measures, were not arbitrary and capricious. The Ninth Circuit Court of Appeals concluded that the RPA was arbitrary and capricious, because NMFS did not analyze how implementation of the short – term measures of the RPA, for 8 of 10 years of the plan for Project operations, would avoid the likelihood of jeopardy to coho salmon. The Ninth Circuit Court of Appeals remanded the case to the district court for appropriate injunctive relief.[1] On remand, the district court granted a motion for injunctive relief and ordered: (1) NMFS and Reclamation to reinitiate consultation on the Klamath Irrigation Project; (2) NMFS to issue a new BiOp based on the current scientific evidence and the full risks to threatened coho salmon; and (3) Reclamation to limit Project irrigation deliveries if they would cause flows in the Klamath River at and below IGD to fall below 100 percent of the Phase III flow levels specifically identified by NMFS in its 2002 BiOp as necessary to prevent jeopardy (i.e., Table 9 in the 2002 BiOp), until the new consultation for the Klamath Irrigation Project was completed.[2]

In 2007, Reclamation reinitiated consultation with the NMFS and the USFWS on its ongoing operations of the Project. Reclamation proposed to change its ongoing activities to address concerns with monthly time-step management of downstream flows and UKL elevations. Reclamation also sought to address the court order, which dictated that Reclamation must meet Phase III flow levels in the RPA of the NMFS' 2002 BiOp for Reclamation's Project operations until a new BiOp was developed. The USFWS completed a non-jeopardy BiOp on the Project for the LRS and the SNS in April 2007. The NMFS issued a draft jeopardy BiOp on the Project for the SONCC coho salmon ESU in June 2008. On October 6, 2008, Reclamation requested that the NMFS suspend the finalization of the consultation until further notice. On March 4, 2010, Reclamation requested that the NMFS finalize its BiOp on the Project. On March 18, 2010, NMFS released its BiOp (NMFS 2010a) on Reclamation's Project operations from 2010–2018, and concluded that Reclamation's proposed operations would likely jeopardize the continued existence of SONCC coho salmon and would likely destroy or adversely modify SONCC coho salmon designated critical habitat; the BiOp also included a RPA.

2.1.1 Oregon Water Rights Adjudication

This proposed action was developed beginning in 2011 and finalized in December 2012. On March 7, 2013, the Oregon Water Resources Department delivered the Findings of Fact and an Order of Determination in the Klamath River Basin Adjudication regarding water rights in the Klamath Basin (within the state of Oregon) to the Klamath County Circuit Court. Adjudication-related proceedings in the Oregon portion of the Klamath Basin have been conducted since 1975, and the completion date was unknown as the proposed action was developed. Because the Findings of Fact and Order of Determination were unknown as the proposed action was developed, or even when the Oregon Water Resources Department might complete the Findings of Fact and Order of Determination, the proposed action does not anticipate or account for the

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[1] *Pacific Coast Federation of Fishermen's Associations v. U.S. Bureau of Reclamation*, 426 F.3d 1082 (9th Cir. 2005).

[2] *Pacific Coast Federation of Fishermen's Associations v. U.S. Bureau of Reclamation*, 2006 WL 798920 (N.D. Cal. 2006), *amended on reconsideration*, 2006 WL 1469390 (N.D. Cal. 2006), *affirmed*, 226 Fed. Appx. 715, 2007 WL 901580 (9th Cir. 2007).

Findings of Fact and Order of Determination. The potential effects of the Findings of Fact and Order of Determination on management of water in the Klamath Basin, including the Reclamation's Project operations, are uncertain at present and will likely remain uncertain for several years. Therefore, the proposed action is not modified based on the Findings of Fact and Order of Determination. In the future, when the consequences of the adjudication are understood, the proposed action will be modified if necessary in accordance with parties' legal rights to beneficial use of water.

2.2 History of Consultation

This joint BiOp is the culmination of a multi-year collaborative effort among Reclamation, the USFWS, and the NMFS to develop a new proposed action for ongoing operations of the Project. The need to reconsult was identified in 2010 when the issuance of the NMFS's 2010 jeopardy BiOp with a RPA combined with Project water use resulted in UKL levels that were lower than analyzed by the USFWS in its 2008 BiOp on the Project. Reclamation and the Services agreed that under certain hydrologic conditions, Reclamation was unable to meet the water needs of the Project and the Services' BiOps, resulting in conflicting requirements that were difficult for Reclamation to meet with actions under its discretion. Because there was a need to have coordinated BiOps for the Project, the USFWS Pacific Southwest Regional Director, the NMFS Southwest Regional Administrator and Reclamation's Mid Pacific Regional Director met in November 2010 with their respective field office managers and directed them to develop a new proposed action and joint BiOp. The goal of this directive was to ensure the development of a workable proposed action and a joint BiOp that would allow Reclamation to continue to operate the Project to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable State and Federal law while meeting the conservation needs of affected listed species in a coordinated manner.

A team of Federal resource managers was convened in early 2011 to establish an Agency Coordination Team. The Agency Coordination Team consists of hydrologists, biologists, managers from each agency, and support staff. The team met on over 25 occasions (see Table 2.1) and created a new paradigm and decision-making process for managing Reclamation's Project in a manner that provides more certainty for Project water users, UKL elevations, and Klamath River flows than in the past.

Table 2.1 Chronology of Agency Coordination Team meetings for development of Reclamation's proposed action.

Date	City	State
May 10, 2011	Redding	CA
June 2-3, 2011	Medford	OR
June 22-23, 2011	Arcata	CA
July 19-20, 2011	Klamath Falls	CA
August 15, 2011	Teleconference	
September 13-14, 2011	Ashland	OR
October 4, 2011	Klamath Falls	OR
October 18, 2011	Teleconference	
November 8-9, 2011	Arcata	CA
December 6-7, 2011	Redding	CA
January 10-11, 2012	Redding	CA
February 9-10, 2012	Redding	CA
February 17, 2012	Teleconference	
February 28, 2012	Teleconference	
March 14, 2012	Ashland	OR
April 3, 2012	Teleconference	
April 17, 2012	Teleconference	
April 26-27, 2012	Medford	OR
May 3-4, 2012	Teleconference	
May 16-18, 2012	Medford	OR
June 4, 2012	Teleconference	
June 7, 2012	Teleconference	
June 19-20, 2012	Klamath Falls	OR
July24-25, 2012	Teleconference	
August 9, 2012	Teleconference	
September 21, 2012	Teleconference	

On December 1, 2012, Reclamation sent letters requesting initiation of formal consultation pursuant to section 7(a)(2) of the ESA. The Services received Reclamation's request and accompanying BA on December 3, 2012. NMFS also received Reclamation's December 21, 2012, letter clarifying the proposed minimum daily average target flows and the inclusion of a coho salmon conservation measure as part of the proposed action. The USFWS received Reclamation's January 4, 2013, letter revising the effects determination on critical habitat for Lost River sucker and shortnose sucker, and addressing other minor points of clarification. On January 8, 2013, a letter of sufficiency of the BA was sent to Reclamation from the Services.

In Section 4.3.3.5 on page 4-45 of the final BA (Reclamation 2012), Reclamation included as part of the proposed action information on mowing roads and dikes and the use of pesticides and herbicides on Project lands. The BA states the effects of these activities have been evaluated in previous ESA section 7 consultations (1-7-95-F-26 and 1-10-07-F-0056), and there are no proposed changes to the vegetation and pest management activities as currently practiced. On February 8, 2013, Reclamation clarified via email that the information on pesticide use as noted in Section 4.3.3.5 was included in the BA to respond to USFWS's request to provide a complete Baseline of Project operation, and Reclamation is not requesting consultation on pesticide use as part of their request for formal consultation.

Additionally, as part of their proposed action in the final BA, Reclamation included a statement that in dry years when the Project Supply is limited, it may not be possible to maintain the proposed minimum Tule Lake Sump 1A elevations because of decreased runoff and drainage from Project land. Reclamation stated in the first paragraph on page 4-38 of the BA (Reclamation 2012) that this situation is outside of their control, and Tule Lake elevations may decline to levels less than the proposed minimums and sucker relocation may be necessary. However, after finalizing the BA, Reclamation conducted further analysis on the likelihood of not meeting minimum elevations in Tule Lake. On April 9, 2013, Reclamation provided this analysis to the USFWS via email, concluding that if the Klamath Project received irrigation deliveries, the likelihood of not maintaining minimum surface elevation in Tule Lake Sump 1A was very rare. Therefore, Reclamation requested via email on April 25, 2013, that the paragraph on page 4-38 and associated Appendix 4B be removed from the proposed action and not analyzed.

On May3, 2013, USFWS received Reclamation’s letter, clarifying and updating the proposed action with additional Conservation Measures. These measures included providing an additional $500,000 in FY2013 to support captive propagation; capturing and transporting listed suckers in Lake Ewauna and releasing them in UKL; and investigating the reduction of flows at Link River Dam to determine if there are feasible management options to minimize effects of entrainment at Link River Dam on larvae and juvenile listed suckers at key times when they are present at the south end of UKL.

On May 7, 2013, Reclamation and NMFS met in Medford, OR to discuss several issues NMFS needed to be addressed prior to issuance of the anticipated, joint BiOps on Reclamation’s proposed action. The issues involved the minimum flows during the spring, magnitude and frequency of high flow events, and the restoration funding.

On May 10, 2013, NMFS received Reclamation’s May 9, 2013, letter documenting the mutual agreement between NMFS and Reclamation to extend the consultation on the endangered southern resident killer whale DPS (*Orcinus orca*) for one year.

On May 29, 2013, NMFS received Reclamation’s letter revising the proposed action to further minimize adverse effects of the Project on the SONCC coho salmon ESU and its critical habitat. The revised proposed action consists of: (1) increasing the minimum daily IGD flow targets for April, May, and June; (2) clarifying flexibility in operations regarding meeting minimum daily average flows downstream of IGD; (3) clarifying that the proposed action daily modeled IGD flows during high flow events will be achieved during real-time operations; (4) increasing annual fisheries habitat restoration funding to $500,000; and (5) using adaptive management for minimizing fish disease.

3 ACTION AREA

The action area includes “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 C.F.R. § 402.02).

For purposes of the USFWS’s BiOp, the action area includes UKL in south central Oregon, and Gerber Reservoir and Clear Lake in the Lost River drainage of southern Oregon and northern California downstream to IGD (Figure 3.1). Please note that Clear Lake and Clear Lake Reservoir are the same water-body and the names are used interchangeably throughout this document. Within the Upper Klamath Basin, the action area includes Agency Lake, UKL and its tributaries, Keno Reservoir (also called Lake Ewauna), the Lost River including Miller Creek, and all Reclamation-owned facilities including reservoirs, diversion channels and dams, canals, laterals, and drains, including those within Tule Lake and Lower Klamath National Wildlife Refuges (Figure 3.2). The UKL tributaries are included in the action area because the conservation measures for listed suckers are likely to occur in these tributaries, not because the Project operations affect these species or their habitat within the tributaries.

For the NMFS, the action area includes the mainstem Klamath River from IGD at River Mile (RM) 190 to the Klamath River mouth, as well as tributaries between IGD and the Salmon River. The Klamath River tributaries are part of the action area because one of the proposed conservation measures focuses on providing benefits to coho salmon populations within these tributaries.

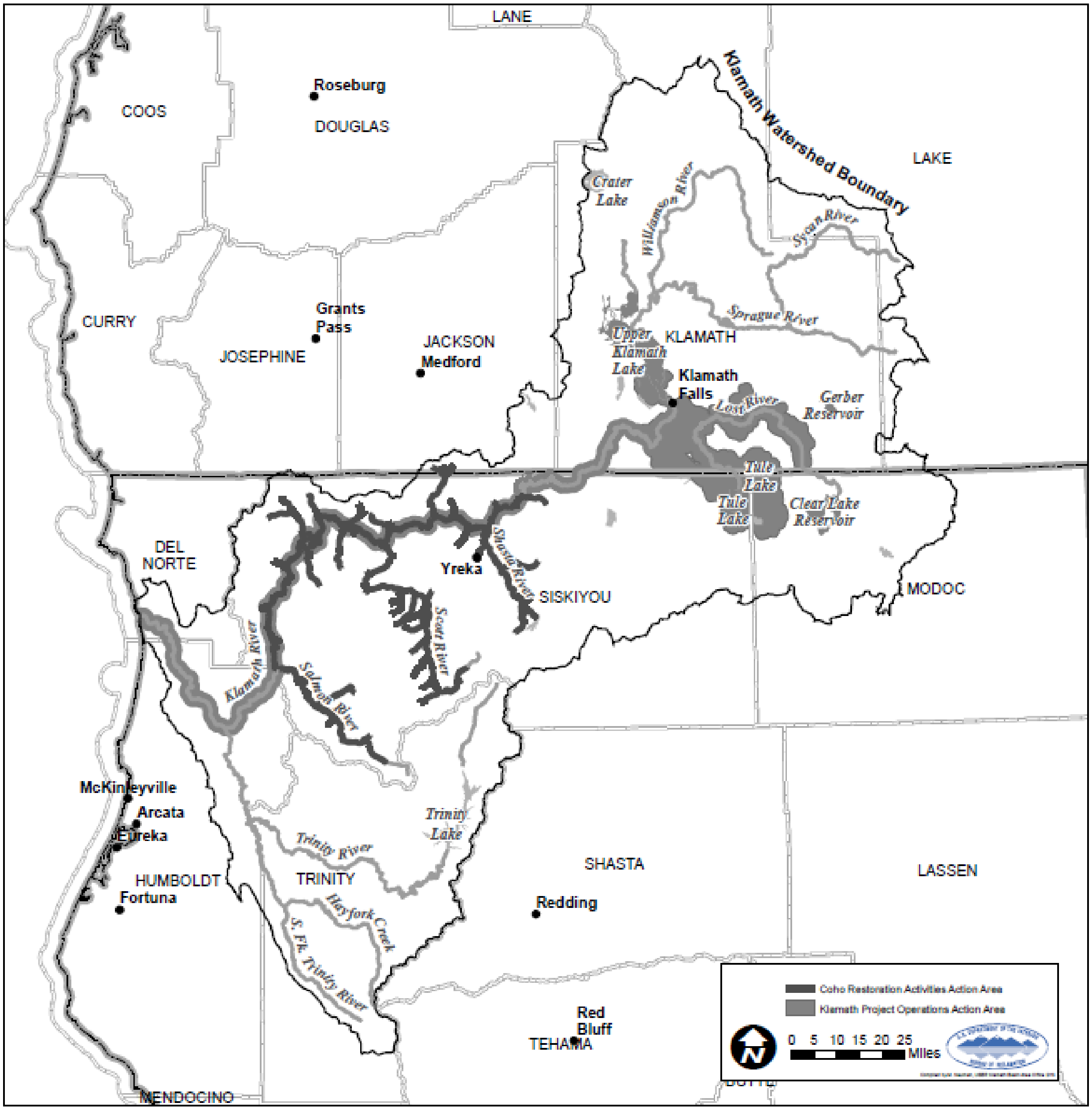


Figure 3.1. The action area for Reclamation's proposed action.

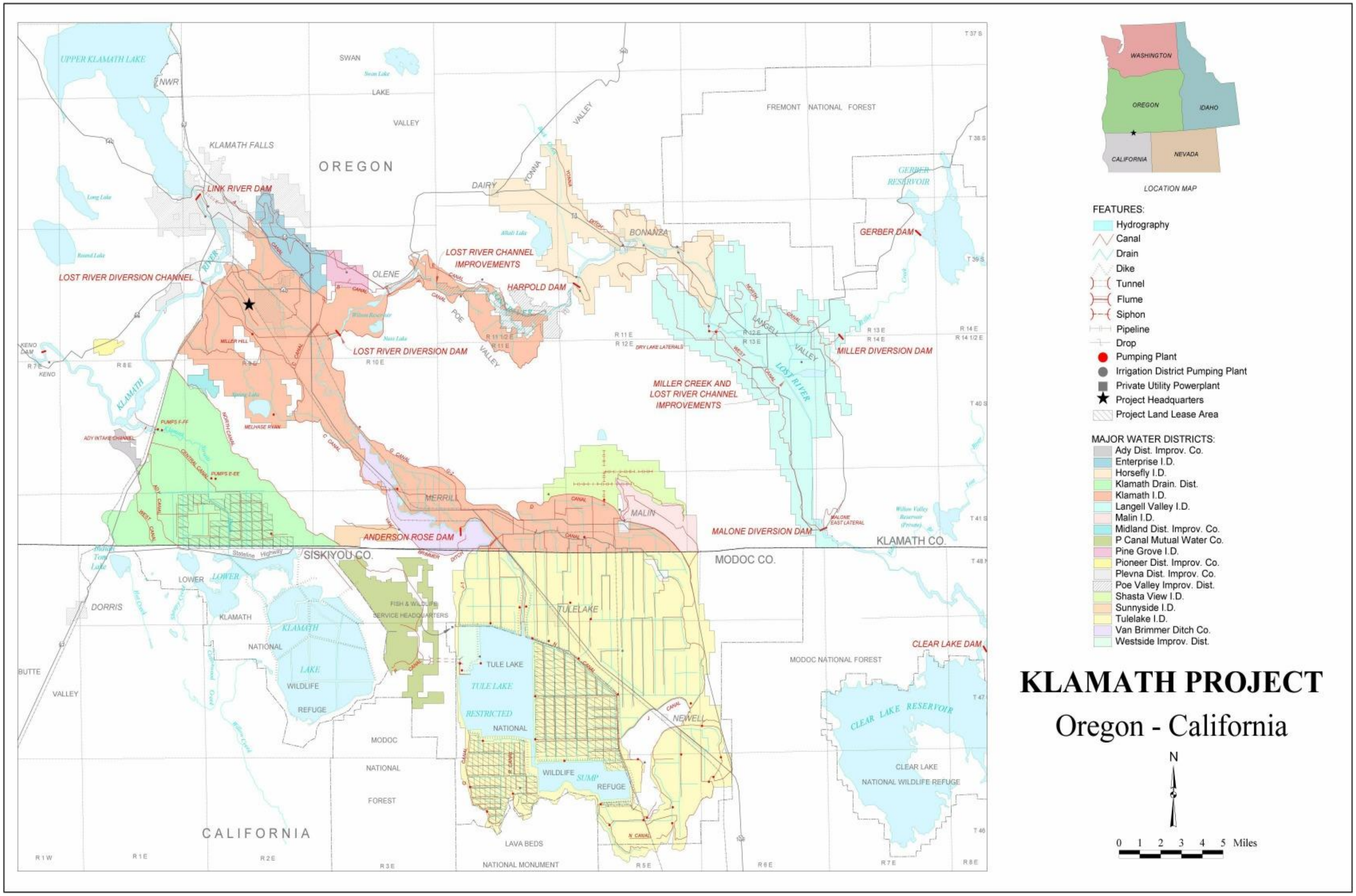


Figure 3.2. Location of the Project in the Upper Klamath River Basin of Oregon and California (Reclamation 2013a).

4 PROPOSED ACTION

Reclamation proposes to continue to operate the Project to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable State and Federal law. Reclamation also proposes to carry out the activities necessary to maintain the Project and ensure its proper long-term functions and operation. The period covered by this proposed action is the signature date of this BiOp through March 31, 2023.

Reclamation's proposed Project operations from 2013 to 2023 consist of three major elements:

1. Store waters of the Klamath and Lost Rivers.

2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability, while maintaining lake and river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.

3. Perform operation and maintenance (O&M) activities necessary to maintain Project facilities to ensure proper long-term function and operation.

Each of the elements of the proposed action is described in greater detail in the following sections. Elevations used in this section are referenced to Reclamation's datum for the upper Klamath Basin, which is 1.78 feet higher than the National Geodetic Vertical Datum of 1929.

4.1 Element One

Store waters of the Klamath and Lost Rivers.

4.1.1 Annual Storage of Water

Reclamation plans to store water annually in UKL, Clear Lake, and Gerber Reservoir. The majority of inflow occurs from November through May. In some years of high net inflows or atypical inflow patterns, contributions to the total volume stored can also be significant in October and June. The majority of water delivery from storage occurs during April through September, although limited delivery occurs in March, October, and November. Storing water through the winter and spring results in peak lake and reservoir storage between March and May.

The Klamath Project's primary storage reservoir, UKL, is shallow and averages only about 6 feet (ft) (1.8 meters [m]) of usable storage when at full pool (approximately 515,000 acre-feet). Clear Lake and Gerber Reservoir also have limited storage capability. Thus, UKL, Clear Lake, and Gerber Reservoir do not have the capacity to carry over significant amounts of stored water from one year to the next. UKL also has limited capacity to store higher than normal inflows during spring and winter months, because the levees surrounding parts of UKL are not adequately constructed or maintained for that purpose. Therefore, the amount of water stored in any given year is highly dependent on net inflows in that year, and in preceding years. Inflow throughout the irrigation season is predominantly dependent upon snowpack to sustain flows during the summer and fall months. Ground water is an important component of inflow to UKL and also for summer and fall base flow in tributaries to UKL. However, without adequate snowpack, sufficient water may not be available to meet all needs.

4.1.2 UKL Flood Prevention Threshold Elevations

While balancing the need for storing water, Reclamation must also evaluate the available storage capacity in UKL to prevent flooding. Adequate storage capacity must be maintained in UKL to capture high runoff events and avoid potential levee failure. Maximum UKL elevation thresholds for flood protection (Table 4.1) are not intended to be exceeded. Flood prevention releases from Link River Dam occur any time UKL elevations appear likely to exceed elevations that put lakeshore levees at risk of failure or being overtopped.

Flood protection elevations vary in January through April depending on the Natural Resources Conservation Service (NRCS) UKL 50 percent exceedance net inflow forecast for March through September. When the forecast exceeds 710,000 acre-feet, lower flood release threshold elevations are implemented. This allows for a greater margin of safety when high inflows to UKL are anticipated. The UKL flood prevention elevations are intended to be used as guidance; in the actual operation of UKL, professional judgment will be utilized in combination with hydrologic conditions, snowpack, forecasted precipitation, and other factors to ensure the protection of UKL levees and the public.

Table 4.1 UKL flood release threshold elevations for the last day of each month under relatively dry or wet conditions.

Month	Drier Condition Elevation (Forecast ≤ 710,000 acre-feet)	Wetter Condition Elevation (Forecast >710,000 acre-feet)
October	4141.40 ft (1,262.30 m)	4141.40 ft (1,262.30 m)
November	4141.60 ft (1,262.36 m)	4141.60 ft (1,262.36 m)
December	4141.80 ft (1,262.42 m)	4141.80 ft (1,262.42 m)
January	4,142.30 ft (1,262.57 m)	4,142.00 ft (1,262.48 m)
February	4,142.70 ft (1,262.70 m)	4,142.40 ft (1,262.60 m)
March	4,143.10 ft (1,262.82 m)	4,142.80 ft (1,262.73 m)
April	4,143.30 ft (1,262.88 m)	4,143.30 ft (1,262.88 m)

4.2 Element Two

Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability, while maintaining lake and river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.

4.2.1 General Description

The Klamath Project has two distinct service areas: the east side and the west side. The east side of the Project includes lands served primarily by water from the Lost River, and Clear Lake and Gerber Reservoirs. The west side of the Project includes lands that are served primarily by water from UKL and the Klamath River. The west side also may use return flows from the east side. The Project is operated so that flows from the Lost River and Klamath River are controlled, except during high inflow periods. The Project was designed based on reuse of water. Therefore, water diverted from UKL and the Klamath River for use within the west side is reused several times before it discharges back into the Klamath River via the Klamath Straits Drain. Return flows from water delivered from the reservoirs on the east side are also reused several times.

Water management relies heavily on seasonal water supply forecasts provided by NRCS for the Williamson River, UKL, Clear Lake, and Gerber Reservoir. The water supply forecasts are developed based on antecedent streamflow conditions, precipitation, snowpack, current hydrologic conditions, a climatological index, and historical streamflow patterns (Risley et al. 2005). NRCS updates the forecasts for the season early each month from January to June, with mid-month updates through June. The forecasts are used to estimate seasonal net inflow to these bodies of water and in models used to simulate water management scenarios for the Project, UKL, Klamath River, and refuges. The inflow forecasts are estimates; observed inflows typically vary substantially from forecasted inflows. Variation in the forecasts ranges from 1 or 2 percent to over 100 percent, depending on the timeframe of the forecast (March through September for example) and the month in which it was issued.

A detailed description of the NRCS inflow forecasting procedures is located at the following NRCS web sites: *http://www.wcc.nrcs.usda.gov/factpub/wsf_primer.html* and *http://www.wcc.nrcs.usda.gov/factpub/intrpret.html*

For the purpose of estimating future Project needs, yearly demands for irrigation supply and refuge deliveries are assumed to be similar to those that have occurred in the period of record (POR). The irrigation demand is the amount of water required to fully satisfy the irrigation needs of the Project. Historical demands during the POR result from a large range of hydrologic and meteorological conditions, and are expected to be a reasonable representation of future demand during the 10-year period of this proposed action.

4.2.2 Operation of the East Side of the Klamath Project

The east side of the Project consists of approximately 37,000 acres (ac) (15,000 hectares [ha]) of irrigable land and reservoirs, dams, canals, laterals, drains, and pumping plants. The east side diverts water from Clear Lake and Gerber Reservoirs. Although the water year is October 1 to

September 30 of each year, delivery of water to the east side of the Project occurs primarily from mid-April through the end of September. East side Project features are shown in Figure 3.2.

These two east side reservoirs store water to meet irrigation needs of the east side and prevent flooding in and around Tule Lake. Water from Clear Lake and Gerber Reservoirs principally serve Langell Valley Irrigation District, Horsefly Irrigation District, and private Warren Act contract lands. However, water from return flows and accretions can be delivered to other Project lands through the Lost River and Lost River Diversion Channel system. Irrigation water on the east side is managed to minimize flow passing Harpold Dam, a Horsefly Irrigation District facility. Water that does flow past Harpold Dam is used by irrigators or diverted into the Lost River Diversion Channel, where it may be used on the west side of the Project or routed to the Klamath River.

Water released from Clear Lake Reservoir primarily serves land west of the Lost River, and is diverted into the West Canal through headworks located at Malone Dam, approximately 12 miles (mi) (19 kilometers [km]) below Clear Lake. Only irrigation releases are made from Clear Lake Dam unless required by an emergency situation. Emergency situations for Clear Lake and Gerber Reservoirs may include, but are not limited to, flood control, dam failure, and inoperable gates.

Water released from Gerber Reservoir primarily serves lands east of the Lost River, and is diverted into the North Canal through a diversion structure on Miller Creek approximately 6 mi (10 km) below Gerber Reservoir. The North Canal provides water to the Langell Valley Irrigation District. During the irrigation season, no water is released into Miller Creek below the diversion structure; however, return flows from irrigation of adjacent lands and dam leakage provide some flow in Miller Creek. When irrigation water is not used, water flows down Miller Creek to the Lost River.

The POR for hydrologic and Project data for this proposed action as it relates to the east side of the Project is 1903 through 2012 for Clear Lake Reservoir, and 1925 through 2012 for Gerber Reservoir. The POR includes a broad range of hydrologic conditions that likely encompasses the range of future conditions that may occur within the 10-year period covered by the proposed action.

Reclamation proposes to operate the east side of the Project as described below.

4.2.2.1 Clear Lake Operations

Under the proposed action, Clear Lake is generally expected to provide water sufficient to meet irrigation demand, which is anticipated to be near the long-term average of approximately 34,000 acre-feet annually. Water is generally used between April 15 and September 30, with the outlet at Clear Lake Dam typically opened on April 15 and closed on October 1. The average release rate is approximately 120 cubic feet per second (cfs; 3.4 m^3/sec) with a typical maximum irrigation release of approximately 170 cfs (4.8 m^3/sec).

Clear Lake has a winter carryover storage capacity of approximately 350,000 acre-feet, corresponding to a maximum water surface elevation of 4,536.40 ft (1,382.70 m) between

October 1 and March 1. The proposed maximum operational water surface elevation is 4,537.40 ft (1,383.00 m) between March 2 and September 30. Elevations can reach a temporary maximum of 4,543.00 ft (1,384.71 m) for flood storage purposes; however, water must be released any time elevations are greater than 4,537.40 ft (1,383.00 m; R. Madsen, Reclamation, pers. comm. 2013).

Based on the POR, the 5 percent exceedance elevation occurs in April and is 4,539.26 ft (1,383.57 m). The 95 percent exceedance elevation occurs in September and is 4,519.42 ft (1,377.52 m). The proposed end of September minimum elevation is 4,520.60 ft (1,377.88 m).

Available water from Clear Lake is estimated annually using a seasonal forecasting model developed by Reclamation (different from the Water Resource Integrated Modeling System [WRIMS] model used to develop the proposed action; see Section 4.2.3 for more information on WRIMS). The model accounts for the NRCS inflow forecast, typical irrigation delivery patterns, seepage, and evaporation. Reclamation estimates available water supplies and appropriate deliveries that will ensure an end of September Clear Lake elevation greater than the proposed minimum elevation of 4,520.60 ft (1,377.88 m). Reclamation continues to evaluate these estimates throughout the irrigation season to ensure the end of September elevation is met. Irrigation demands are dictated by the Horsefly Irrigation District and other contracted private users along the Lost River.

4.2.2.2 Gerber Reservoir Operations

Under the proposed action, Gerber Reservoir is expected to provide water sufficient to meet irrigation demand, which is anticipated to be near the long-term average of approximately 35,000 acre-feet annually. Water is generally used between April 15 and September 30, with the outlet at Gerber Dam typically opened on April 15 and closed on October 1. The average release rate is approximately 120 cfs (3.4 m^3/sec) with a typical maximum irrigation release of approximately 170 cfs (4.8 m^3/sec).

Gerber Reservoir has a winter carryover storage capacity of approximately 55,000 to 65,000 acre-feet, corresponding to a maximum water surface elevation of approximately 4,833.00 ft (1,473.10 m) between October 1 and March 1. The proposed maximum operational elevation is approximately 4,836.00 ft (1,474.01 m) between March 2 and September 30. A temporary maximum elevation for flood storage has not been defined; however, Reclamation considers potential flood control releases could be required when elevations are greater than 4,835.40 ft (1,473.83 m) and a substantial snowpack is present (R. Madsen, USBR, pers. comm. 2013).

Based on the POR, the highest elevations occur in April and the lowest elevations occur in October. The proposed end of September minimum elevation is 4,798.10 ft (1,462.46 m).

Historically, approximately 2 cfs (0.06 m^3/sec) of water was released into Miller Creek during the winter to prevent a valve in Gerber Dam from freezing. Recently, however, the discharge has been increased to approximately 5 cfs (0.14 m^3/sec) to minimize the potential for stranding suckers in pools below the dam and ensure water quality is adequate to support suckers. Reclamation intends to continue the 5 cfs (0.14 m^3/sec) releases into Miller Creek from Gerber Reservoir as part of this proposed action.

Available water from Gerber Reservoir is estimated annually using a seasonal forecasting model developed by Reclamation, similar to that for Clear Lake. The model accounts for the NRCS inflow forecast, typical irrigation delivery patterns, seepage, and evaporation. Reclamation estimates available water supplies and appropriate deliveries that will ensure an end of September Gerber Reservoir elevation greater than the proposed minimum elevation of 4,798.10 ft (1,462.46 m). Reclamation continues to evaluate this estimate throughout the irrigation season to ensure that the end of September minimum elevation is met. Irrigation demands are dictated by the Langell Valley Irrigation District, Horsefly Irrigation District, and other contracted private users along the Lost River.

4.2.3 Operation and Delivery of Water on the West Side of the Klamath Project

The west side of the Project consists of approximately 170,000 ac (68,797 ha) of irrigable land and numerous reservoirs, dams, channels, canals, laterals, drains, and pumping plants. The west side diverts water directly from UKL or the Klamath River. Although the water year is October 1 to September 30, delivery of water to the Project occurs primarily from early April through mid-October. However, limited water is delivered to the Project between October and March.

Major Project delivery facilities associated with the west side include the following: The A Canal divers water from UKL approximately 1,700 ft (518 m) upstream from Link River Dam and delivers irrigation water, either directly or through return flows, to a large portion of the Project. The Lost River Diversion Dam (“Wilson Dam”), located on the Lost River near the town of Olene, Oregon, diverts water from the Lost River into the Lost River Diversion Channel for irrigation and flood control of Tule Lake reclaimed lands. The Lost River Diversion Channel begins at the Lost River Diversion Dam and is routed to the west where it terminates at the Klamath River in Keno Reservoir. The Lost River Diversion Channel is designed so that water can flow in either direction, depending on operational requirements. During irrigation season, the predominant direction of flow is from the Klamath River to the Lost River system. During the non-irrigation season, flow is typically from the Lost River system to the Klamath River. Anderson-Rose Diversion Dam is located on the Lost River downstream from the Lost River Diversion Dam, and feeds the main distribution canal for Tulelake Irrigation District. Ady and North Canals divert water from Keno Reservoir to the Lower Klamath area, and serve Klamath Drainage District, Lower Klamath National Wildlife Refuge (NWR), and the Area K Lease Lands, which are part of Lower Klamath NWR. Delivery facilities that provide winter irrigation and Lower Klamath NWR water include Ady and North Canals. Station 48 also delivers water into November in some years. Project features are shown in Figure 3.2.

The POR for hydrologic and Project data for this proposed action as it relates to UKL and the operations of the west side of the Project is water year 1981 through 2011, in large part because NRCS has reconstructed its historical forecasts for the Williamson River and UKL back through the 1981 water year. NRCS reconstructions are based on improved algorithms and updated daily UKL net inflow and Williamson River flow volume calculations. Reconstructed forecasts are not available prior to water year 1981. The proposed action relies heavily on these forecasts as described in the *Spring/Summer Operations* section (section 4.2.3.2).

Reclamation incorporated the 1981 through 2011 dataset into WRIMS to assess the effects of the proposed action as it relates to operations on the west side of the Project. WRIMS, formerly called CALSIM, is a generalized water resources model for evaluating operational alternatives of large, complex river basins. In previous consultations, the WRIMS model used monthly data and could only provide output on a monthly time step. For this consultation, a substantial effort was made to convert the available monthly data into a daily dataset, and upgrade the WRIMS model to a version that uses daily data and provides output on a daily time step. Daily datasets compiled and calculated for the new version of the model include UKL net inflow, west side of the Project historical use, Keno Reservoir accretions, and Keno Dam to IGD accretions.

The version of WRIMS used to model various proposed action scenarios is referred to by Reclamation (Reclamation 2012) as the Klamath Basin Planning Model (KBPM). The specific model study of the proposed action is named 2L_MW_7_O, distributed on December 7, 2012.

Although the model is called a planning model, it is also an operational model in the sense that it provides specific guidance and procedures for management and allocation of water throughout the water year. The order in which water management procedures are conducted and decisions made during operation of the proposed action are specifically intended to be the same as those used in the model. The equations upon which decisions are made during operations are the exact equations used in the model, and the order in which equations are applied and decisions made are intended to be the same operationally as in the model.

The KBPM includes data for the west side of the Project, the Williamson River, UKL, and the Klamath River between Link River Dam and IGD. The KBPM does not explicitly model Clear Lake, Gerber Reservoir, or the Lost River on the east side of the project. However, the net effects on the west side of the Project and Klamath River that result from east side operations and hydrologic conditions are included in the model via the gains and losses from the Lost River Diversion Channel. The KBPM also does not model operational details for facilities on the Klamath River, such as IGD or other reservoirs owned and operated by PacifiCorp. Operation of the west side of the Project was simulated over the POR using daily input data to obtain daily results for Klamath River flows, Project diversions (including the Lower Klamath NWR), and UKL elevations and storage. Daily results are converted to 3- or 7-day moving averages or weekly, monthly, and annual volumes during evaluation of the model results, depending on how the user chooses to view and use the model output.

Three primary elements derived from the model and included in the proposed action are the concepts of Project Supply, Environmental Water Account (EWA), and Upper Klamath Lake Reserve (UKL Reserve). These are defined as follows:

> The <u>Project Supply</u> is defined as the volume of water provided from UKL to the Project for irrigation use between March 1 and September 30 of any given water year.
>
> The <u>EWA</u> is defined as the volume of water available from UKL to the Klamath River for instream flow between March 1 and September 30 of any given water year.

> The UKL Reserve is defined as the usable storage volume (above an elevation of 4,136.00 ft [1260.65 m]) in UKL on September 30 of each water year. Similar to the Project Supply and EWA, the UKL Reserve is initially determined on March 1.

Note that although the water volumes for each of the Project Supply and EWA are for March 1 through September 30, these supplies of water are not required to be fully used by September 30, and may be used through November of the following water year.

The KBPM is a critical tool for evaluation of possible water management. However, not all of the processes built into the model can be implemented during operations exactly as they were simulated. For example, the model uses patterns of irrigation water distribution on a monthly basis to simulate delivery of water to the Project. The distribution patterns were developed by analyzing historical irrigation demand and calculating an average percent distribution for each month during water years ranging from substantially drier than average to substantially wetter than average.

Real-time implementation of the proposed action will not result in the same irrigation delivery distribution patterns. Similarly, the UKL Reserve and distribution of the EWA will be different operationally than simulated. However, the results of actual operations are anticipated to be within the upper and lower bounds of the simulated results (e.g., Klamath River flows at IGD, UKL elevations, and Project Supply), assuming that climate and hydrologic conditions occurring during the life of the proposed action are within the range of conditions observed in the POR used for modeling the proposed action.

A detailed description of WRIMS model study 2L_MW_7_O is included in Appendix 4A-1, Model Documentation of Reclamation's Biological Assessment (Reclamation 2012).

4.2.3.1 Fall/Winter Operations

Water management from October through February will follow a formulaic approach focused on meeting the needs of coho salmon in the Klamath River while increasing water storage in UKL and providing fall/winter water deliveries to the Project and Lower Klamath NWR. This approach attempts to ensure adequate water storage and sucker habitat in UKL while providing variable river flows that mimic natural hydrology, based on real-time hydrologic conditions in the upper Klamath Basin. The fall/winter Klamath Project operational procedure distributes the available UKL inflows as described below. Additional details are included in Reclamation's BA (Reclamation 2012).

The primary goals of fall/winter water management are to:

- Increase the UKL elevation to meet listed species habitat needs and increase storage for spring/summer EWA releases and irrigation deliveries.

- Release sufficient flow from Link River Dam to meet listed species needs in the Klamath River.

- Provide Project irrigation deliveries to:
    - Klamath Drainage District (Area A2 from North Canal and Ady Canal)
    - Lease Lands in Area K (Area A2 from Ady Canal)
    - Lower Klamath National Wildlife Refuge (from Ady Canal)

To satisfy these goals for fall/winter water management, Reclamation will determine a flow release target from Link River Dam in real-time, using the series of steps and equations described below. The flow release target from Link River Dam combined with accretions downstream from Link River Dam is intended to provide at least minimum daily target flows below IGD, and flows greater than minimums when hydrologic conditions allow. IGD proposed average daily minimum target flows are 1,000 cfs (28.3 m^3/sec) in October and November, and 950 cfs (26.9 m^3/sec) in December, January, and February.

In several water years during the POR, the model simulates a number of daily flows at IGD that are less than the minimum daily average target flows. This is because the model simulates a one-day time lag between flow releases at Link River Dam and flow at IGD. The one-day time lag combined with variability in accretions results in simulated flows lower than the minimum targets. Real-time implementation of the proposed action will result in increased releases from Link River Dam to ensure that flows meet or exceed the daily minimum average target flows at IGD. In addition, to allow flexibility for the possibility of operator error and uncertainties associated with flow releases at IGD, Reclamation proposes a maximum of a 5 percent reduction in flows below the minimum daily average flows at IGD, for up to a 72-hour duration. If such a flow reduction occurs, Reclamation proposes that the resulting average flow for the month will meet or exceed the associated minimum daily average flow (Reclamation 2013b).

Flow in the Williamson River is the primary hydrologic indicator used to calculate a release target for Link River Dam. As described in more detail below, the initial calculated Link River Dam release target is modified based on several factors, including (1) magnitude of Williamson River flow, (2) rate at which UKL is filling, (3) accretions to the Klamath River below Link River Dam, and (4) any EWA carried over from the previous water year. Williamson River flows used in the modeling environment and during real-time operations are based on daily average flow at the U.S. Geological Survey (USGS) gage number 11512500 (Williamson River below Sprague River, near Chiloquin, Oregon).

4.2.3.1.1 Williamson River Proportion

The previous day's Williamson River average flow is multiplied by the appropriate proportion to calculate an initial Link River Dam flow release. The proportion of the Williamson River flow used to calculate the daily Link River Dam target release is adjusted based on the magnitude of the current Williamson River flow and the month. Higher Williamson River flow results in a greater proportion of inflow released at Link River Dam and lower Williamson River flow results in a lower proportion released. The flow proportion multipliers corresponding to specific Williamson River flows are presented in Table 4.2. Intermediate flow proportion multipliers are obtained by linear interpolation.

Table 4.2. Williamson River proportion targeted for release at Link River Dam.

October		November		December		January		February	
WillQ$_{-1}$ (cfs)	Will_prop	WillQ$_{-1}$ (cfs)	Will_prop	WillQ$_{-1}$ (cfs)	Will_prop	WillQ$_{-1}$ (cfs)	Will_prop	WillQ$_{-1}$ (cfs)	Will_prop
< 500	1.0	< 500	1.0	< 450	0.85	< 450	0.85	< 450	0.85
650	1.25	1173	1.25	800	0.9	800	0.9	800	0.9
1000	2.0	3192	2.0	1000	1.5	1000	1.5	1000	1.5
≥ 4000	2.3	≥ 4000	2.3	2000	1.9	2000	1.9	2000	1.9
				≥ 4000	2.3	≥ 4000	2.3	≥ 4000	2.3

"WillQ$_{-1}$" is the average flow of the Williamson River the previous day in cfs.

"Will_prop" is the proportion of yesterday's Williamson River flow targeted for release from Link River Dam

4.2.3.1.2 UKL Fill Rate Adjustment

The UKL fill rate adjustment changes the proportion of the Williamson River flow intended for release at Link River Dam to account for the fill trajectory in UKL. The adjustment is applied only after November 15. The fill rate adjustment is not applied in October and the first half of November because this is a critical time biologically for listed coho on the Klamath River. Fill rate adjustment multipliers for wet and dry hydrologic conditions are presented in Table 4.3. Intermediate values of the fill rate adjustment factor are obtained by linear interpolation, based on the fill rate differential calculated that day.

Table 4.3. UKL fill rate adjustment factor.

Fill_rate_diff (ft/day)	Fill_rate_adjust_wet	Fill_rate_adjust_dry
< -0.02	0.6	0.2
0	1.0	1.0
> 0.03	1.4	1.0

“Fill_rate_diff” is the difference between the recent fill rate of UKL and the average fill rate needed to reach 4,142.80 ft (1,262.73 m) on March 1. Positive values indicate recent fill rates exceed the average rate needed to reach 4,142.80 ft (1,262.73 m) on March 1. Negative values indicate recent fill rates are less than the average rate needed to reach 4,142.80 ft (1,262.73 m) on March 1.

The “wet” and “dry” modifiers to the fill rate adjustment term are defined by the UKL cumulative inflow index. The UKL cumulative inflow index (Upper Klamath Lake_cum_inf_ind) is not calculated by the model, but instead is part of the model input dataset. Because the model does not calculate the index, it must be calculated on a daily basis during real-time operations over the life of the proposed action, as follows:

Upper Klamath Lake Index =

$$\frac{UKL\ cumulative\ net\ inflow\ from\ September\ 1\ through\ day_{t-1}}{period\ of\ record\ maximum\ cumulative\ net\ inflow\ from\ September\ 1\ through\ day_{t-1}}$$

The day_{t-1} term indicates the value on the previous day. The index is then normalized between 0 and 1. Drier hydrologic conditions are defined as a value of the UKL cumulative inflow index less than 0.30. An index value greater than 0.30 indicates any condition not defined as dry but does not distinguish between average or wet conditions.

4.2.3.1.3 Net Accretion Adjustment

Releases from IGD can be greatly affected by the accretions between Link River Dam and IGD. Low net accretions may result in the need to release more water from Link River Dam to produce calculated IGD flows. High net accretions may result in less water being released from Link River Dam to meet calculated IGD flows. The accretion adjustment modifies Link River Dam releases in all hydrologic conditions between October 1 and November 15. Therefore, higher releases at Link River Dam may offset low seasonal accretions downstream. Although values are included in Table 4.4 for all conditions, the accretion adjustment is applied after November 15 only in relatively dry conditions (defined by an UKL cumulative inflow index value less than 0.30), when accretions below Link River dam are low and the accretion adjustment is necessary to meet calculated IGD flows. Accretion adjustment multipliers are presented in Table 4.4. As with other adjustment factors, intermediate multiplier values are obtained by linear interpolation.

Table 4.4 Net accretion below Link River Dam adjustment factor.

October		November		December		January		February	
Net_ accrete (cfs)	Accrete _adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust
-58	1.2	43	1.2	60	1.2	140	1.0	303	1.0
198	1.2	163	1.2	171	1.2	258	1.0	354	1.0
397	1.0	377	1.0	342	1.0	410	1.0	525	1.0
510	1.0	494	1.0	≥ 415	0	≥ 473	0	≥ 589	0
≥ 585	0.4	≥ 566	0.4						

“Net_accrete” is the value of accretions between Link River Dam and Iron Gate Dam.

“Accrete_adjust” is the multiplier applied to the Link River Dam release target.

4.2.3.1.4 Link River Dam Target Releases

Calculation of releases at Link River Dam is based on the adjustments described above and the month of the year, as shown in Table 4.5.

Table 4.5. Calculation of fall/winter Link River Dam target releases.

Condition	Equation
October through November 15	(Will_prop * Will_Riv_inf$_{-1}$ * Accrete_adjust) + OctNov_augment
November 16 through 30, Upper Klamath Lake_cum_inf_ind < 0.3 (dry)	(Will_prop * Will_Riv_inf$_{-1}$* Fill_rate_adjust * Accrete_adjust) + OctNov_augment
November 16 through 30, Upper Klamath Lake_cum_inf_ind > 0.3 (wet)	(Will_prop * Will_Riv_inf$_{-1}$* Fill_rate_adjust) + OctNov_augment
December through February, Upper Klamath Lake_cum_inf_ind < 0.3 (dry)	Will_prop * Will_Riv_inf$_{-1}$ * Fill_rate_adjust * Accrete_adjust
December through February, Upper Klamath Lake_cum_inf_ind > 0.3 (wet)	Will_prop * Will_Riv_inf$_{-1}$* Fill_rate_adjust

"Upper Klamath Lake_cum_inf_ind" is the UKL cumulative inflow index.

"Will_prop" is the proportion of yesterday's Williamson River flow targeted for release from Link River Dam.

"Will_Riv_inf$_{-1}$" is the Williamson River average flow cubic feet per second the previous day.

"Accrete_adjust" is an adjustment to the Link River Dam release based on net accretions between Link River Dam and Iron Gate Dam.

"OctNov_augment" is based on the volume, if any, of the EWA that was carried over from the previous spring/summer season. The carryover volume is distributed during October and November.

"Fill_rate_adjust" changes the proportion of the Williamson River flow intended for release at Link River Dam from November 16 through February to account for the fill trajectory of UKL.

The fall/winter management steps and Link River Dam release factors are summarized in Table 4.6.

Table 4.6. Fall/winter water management summary.

Date Range	Condition	Common Adjustment Factors	Variable Adjustment Factors
October 1 through November 15	All	Williamson River Proportion Williamson River Flow Yesterday	Accretion Adjustment EWA Carryover Augmentation
November 16 through 30	Dry		Accretion Adjustment Fill Rate Adjustment EWA Carryover Augmentation
	Average to Wet		Fill Rate Adjustment EWA carryover augmentation
December 1 through February 28 or 29	Dry		Accretion Adjustment Fill Rate Adjustment
	Average to Wet		Fill Rate Adjustment

During fall/winter operations, a daily average Link River Dam target release will be calculated based on the above steps and equations. The daily average Link River Dam release will be translated into a daily IGD flow target based on (a) accretions from one week previously for the reach between Link River Dam and Keno Dam, and (b) real-time estimates of accretions between Keno Dam and IGD. Management operations are intended to predict flows at IGD approximately 1 week into the future or, stated differently, with a lead time of approximately 1 week. Therefore, IGD target flows are proposed to be implemented approximately 1 week after flows are observed in the Williamson River. One week between observed flows at the Williamson River gage and when the flows occur at IGD is approximately the travel time for water to flow from the Williamson River gage to IGD under natural hydrologic conditions. The actual transit time will vary based on hydrologic conditions, magnitude of flow, and PacifiCorp's reservoir and dam management operations. Assuming approximately 1 week transit time allows Reclamation, other agencies, stakeholders, and PacifiCorp the ability to coordinate on projected flows below Link River Dam.

In addition, Reclamation will use Williamson River inflow and weather forecasts to estimate likely Link River Dam and IGD flows for an additional week, resulting in a total of 2 weeks of projected flows. The additional 1 week of Link River Dam and IGD flow projection is intended to provide further advanced planning opportunities for resource managers and PacifiCorp. The result of the real-time planning operations described here will be a series of rolling 1- and 2-week projections of releases at Link River Dam and flow at IGD throughout the fall/winter period. Note that the rolling 1- and 2-week projections of releases at Link River Dam and flow at IGD will also be followed during the spring/summer.

Flows below IGD are ultimately the result of the daily Link River Dam target releases, Link River Dam to IGD accretions, and the management of the Klamath Hydroelectric Project by PacifiCorp. Accretions between Link River Dam and Keno Dam are calculated based on flow measurements at the two dams and volumes of water diverted from or to the Klamath River from Klamath Project canals. Accretions between Keno Dam and IGD are based on flow measurements at the two dams, and estimated tributary and groundwater discharge to the Klamath River. Therefore, Reclamation and PacifiCorp will estimate total accretions and add them to the Link River Dam target releases on a near real-time basis. PacifiCorp will be provided flexibility in managing accretions. However, Reclamation, the NMFS, and the USFWS expect that accretions will be passed through the Klamath Hydroelectric Project in a manner consistent with the timing and magnitude of the accretions.

PacifiCorp committed to coordinate with Reclamation to meet the flow-related requirements described in the 2010 NMFS BiOp on Project operations or future consultations between NMFS and Reclamation on Project operations during the Incidental Take Permit term as one of the conservation actions in PacifiCorp's Coho Habitat Conservation Plan (PacifiCorp 2012a) and resulting Incidental Take Permit. PacifiCorp has successfully coordinated with Reclamation to implement the requirements associated with the 2010 NMFS BiOp for the last 3 years, and Reclamation expects this close coordination to continue during implementation of this proposed action.

Emergencies may arise that cause PacifiCorp to deviate from the IGD release target. Emergencies may include, but are not limited to, flood prevention or facility and regional electrical service emergencies. Reclamation will coordinate closely with PacifiCorp should the need to deviate from the IGD flow target be identified. Such emergencies occur infrequently, and are not expected to significantly influence flows downstream from IGD.

Once the Link River Dam and IGD daily target releases are determined, the UKL refill rate is evaluated to calculate the fall/winter water available for delivery to Area 2 of the Project and the Lower Klamath NWR. The availability of water for delivery to the Project or Lower Klamath NWR is evaluated on a daily basis. If UKL is expected to reach an elevation of 4,142.80 ft (1,262.73 m) by March 1, water is made available for delivery to Area 2, Lower Klamath NWR, or both. The timing of requested water deliveries to Area 2 and the Lower Klamath NWR varies from year to year during the fall/winter depending on weather and hydrologic conditions. Therefore, the volume of water determined to be available each day that could have been diverted but was not, accumulates in a fall/winter Project account. Water is delivered to Area 2, Lower Klamath NWR, or both, if demand exists later in the season. Water earmarked for Project or Lower Klamath NWR delivery is not included in the UKL volume/elevation values used to determine the Link River Dam target release. At the end of February, any water not delivered to the Project or Lower Klamath NWR remains in UKL and becomes part of the overall volume available for use as EWA, for the Project, or Lower Klamath NWR during the spring/summer operations period.

In October and November, there is overlap between the spring/summer and fall/winter operations because Area 1 of the Project and/or the Lower Klamath NWR diverts a portion of the spring/summer Project Supply during these months. In addition, a portion of the EWA can be carried over from the preceding spring/summer period for distribution during October and November. The delivery of spring/summer water in October and November is separate from, and does not preclude, delivery of fall/winter water during October and November. Therefore, the spring/summer and fall/winter EWA and diversion accounts will be kept separate during the overlap period.

4.2.3.2 Spring/Summer Operations

Water management from March through September will be implemented using a water supply account approach to meet the needs of coho salmon in the Klamath River, suckers in UKL, and deliveries to the west side of the Project and Lower Klamath NWR. This approach attempts to ensure adequate water storage and sucker habitat in UKL, while providing river flows that offer adequate coho salmon habitat and mimic natural hydrology based on real-time conditions in the Klamath Basin. The spring/summer Klamath Project operational procedure distributes the available UKL inflow and storage as described below. Additional details are included in Reclamation’s BA (Reclamation 2012).

The primary goals of spring/summer water management are to:

- Release sufficient flow from Link River Dam to meet listed species needs in the Klamath River.
- Provide irrigation deliveries to the Project and Lower Klamath NWR.
- Manage UKL elevations to meet listed habitat needs and establish a UKL Reserve for the end of the spring/summer season.

The Project irrigation season is from March 1 through September 30. However, spring/summer irrigation often continues into October and November, depending on the weather, crops planted, and hydrologic conditions at the end of the water year. Spring/summer irrigation season operations will remain consistent with historical Project operations while attempting to (1) provide greater certainty for Project Supply, (2) maintain UKL and Klamath River conditions that avoid jeopardizing the existence of listed species, and (3) avoid adverse modification of critical habitat.

Spring/summer operations are controlled by first defining the total available water supply for the March through September time period on March 1 (UKL Supply), which is based on the end of February UKL storage volume, the NRCS UKL net inflow March through September forecast, and the end of September UKL storage volume modeling objective (UKL Reserve). The UKL Supply is a total March through September volume of water that is updated in April, May, and June to track current hydrologic conditions. The UKL Reserve, Project Supply, and EWA represent the three primary components to which the total UKL Supply will be distributed; (1) EWA specifies the amount of UKL water available to the Klamath River for downstream needs of listed coho salmon, (2) Project Supply is the amount of UKL water available to the Project for the irrigation season, and (3) UKL Reserve is defined as the supply of water to remain in UKL for listed suckers at the end of September.

The EWA, Project Supply, and UKL Reserve are calculated on the first day of March, and updated in April, May, and June based on the available UKL Supply. The April 1 calculation establishes the minimum Project Supply for the water year. The May and June updates accommodate the change in UKL net inflow forecast and observed UKL net inflows by adjusting the EWA and UKL Reserve volumes. The Project Supply also may be adjusted in May and June. However, to provide certainty regarding the minimum Project Supply, the adjustments may not reduce the Project Supply below the volume calculated on April 1. All water released from UKL through the Link River Dam or A Canal between March 1 and September 30, including flood prevention releases, is accounted against the Project Supply or the EWA. Water released through Link River Dam and not diverted to North Canal, Ady Canal, or Lost River Diversion Channel is EWA water. The spring/summer Klamath Project operational procedure distributes the available UKL water as described below. Additional details are included in Reclamation's BA (Reclamation 2012).

4.2.3.2.1 UKL Supply

The UKL Supply is the factor used to determine the March through September water supply, and is initially calculated March 1 using the end of February UKL storage, NRCS forecasted UKL net inflow for March through September, and the end of September modeling objective UKL storage volume (UKL Reserve). The equation is as follows:

March UKL Supply = [End of February UKL storage] + [Forecasted UKL net inflow for March through September] – [End of September UKL storage modeling objective]

April/May/June UKL Supply = [End of February UKL storage] + [March50Volume] – [End of September UKL storage modeling objective].

The UKL storage modeling objective is related to a September 30 UKL elevation the model uses as an objective to calculate UKL Supply. The modeling objective also provides the model with an end of water year UKL elevation based on hydrologic conditions that is a reasonable beginning point for model calculations.

To accommodate the changes in UKL Supply based on updated forecasts and monthly observed UKL net inflow volumes, the model applies a term identified as the March50Volume to track available water supply in its calculations. NRCS provides a monthly UKL net inflow forecast from January through June. The water management decisions in the proposed action are predicated on the March through September UKL net inflow forecast. However, after March, each monthly forecast provides the net inflow volume from the month in which the forecast is issued to the end of September (e.g., April through September, May through September, or June through September). Therefore, the UKL March through September supply is updated with the March50Volume value, defined as the current month UKL net inflow forecast plus the total of the previous month(s) observed UKL net inflow, and is calculated as follows:

- March = [March 1 50 percent exceedance forecast for March through September UKL net inflows]

- April = [April 1 50 percent exceedance forecast for April through September UKL net inflows] + [Observed March UKL net inflow]

- May = [May 1 50 percent exceedance forecast for May through September UKL net inflows] + [The sum of observed March and April UKL net inflows]

- June = [June 1 50 percent exceedance forecast for June through September UKL net inflows] + [The sum of observed March, April, and May UKL net inflows]

4.2.3.2.2 UKL Reserve

The UKL Reserve is determined monthly from March through June. The UKL Reserve is related to an end of September UKL elevation modeling objective (Table 4.7) translated to a storage volume based on the elevation-capacity relationship for UKL (Appendix A). The minimum UKL end of September elevation modeling objective is 4,138.10 ft (1,261.29 m). Intermediate values for the elevation modeling objective are obtained by linear interpolation based on the specific March50Volume.

Table 4.7. UKL end of September elevation modeling objectives based on March50Volume.

March50Volume (acre-feet)	End of September Elevation Modeling Objective ft (m)
210,000	4,138.10 (1,261.29)
310,000	4,138.10 (1,261.29)
620,000	4,138.20 (1,261.32)
830,000	4,138.35 (1,261.37)
1,030,000	4,138.54 (1,261.43)
≥ 1,240,000	4,138.75 (1,261.49)

4.2.3.2.3 Environmental Water Account

The EWA is the volume of water available to the Klamath River from UKL. EWA volumes were developed with consideration of the needs of coho salmon, including effects to their critical habitat. EWA also is calculated monthly from March through June based on available UKL Supply. The percentage of UKL supply dedicated to EWA increases as the supply increases. However, the minimum EWA is 320,000 acre-feet regardless of the supply. Therefore, if the UKL supply is less than 600,000 acre-feet the EWA percentage calculation is replaced by the minimum EWA value. The EWA percentages corresponding to specific UKL supply volumes are shown in Table 4.8. Intermediate EWA percentages are obtained by linear interpolation.

Table 4.8. Environmental Water Account based on UKL Supply.

Upper Klamath Lake Supply (acre-feet)	Environmental Water Account Percentage of UKL Supply
< 600,000*	Not Applicable
600,000	0.53
900,000	0.57
1,100,000	0.63
1,300,000	0.70
≥ 1,500,000	0.78
* If the UKL Supply is less than or equal to 600,000 acre-feet the calculated EWA from the percentages listed results in a volume less than 320,000 acre-feet. When this is the case, the EWA will be set to 320,000 acre-feet regardless of the size of UKL Supply.	

Similar to the fall/winter operations, the model simulates a number of daily flows at IGD that are less than the minimum daily average target flow requirements for IGD shown in Table 4.9. Real-time implementation of the proposed action will increase releases from Link River Dam to avoid flows less than the daily minimum average target flows at IGD. Additionally, IGD releases are proposed to be implemented approximately 1 week after flows are observed in the Williamson River to account for travel time between the Williamson River gage and IGD, and operational constraints. Assuming approximately 1 week transit time allows Reclamation, other agencies, stakeholders, and PacifiCorp the ability to coordinate on projected flows below IGD.

Table 4.9. Proposed minimum spring/summer Iron Gate Dam target flows (cfs).

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
March	1,000 (28.3 m^3/sec)
April	1,325 (37.5 m3/sec)
May	1,175 (33.3 m3/sec)
June	1,025 (29.0 m3/sec)
July	900 (25.5 m^3/sec)
August	900 (25.5 m^3/sec)
September	1,000 (28.3 m^3/sec)

Distribution of the EWA during spring/summer uses the Williamson River as a hydrologic indicator to determine the releases from UKL at Link River Dam. Releases at Link River Dam during spring/summer also take into account accretions between Link River Dam and IGD, UKL fill rate, water released for flood prevention, the volume of EWA that needs to be reserved for the base flow period (June through September), and the volume of EWA already used. This approach produces Link River Dam releases that will, when combined with accretions, provide flows at IGD that generally mimic the Williamson River hydrograph. When spill occurs or adherence to a minimum flow requirement causes releases that are not proportional to the Williamson River flows, the release at Link River Dam is adjusted for the next time step, restoring the proper proportionality.

EWA will be distributed in accordance with the procedures and equations described below.

$$\begin{aligned}\textbf{March, April, and May Link River Dam release} \\ &= \text{Will\_prop\_cum} \\ &* \text{Fill\_rate\_ratio\_spring} * (\text{EWA\_River} - \text{EWA\_reserve} \\ &- \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

“Will_prop_cum” is yesterday’s flow volume in the Williamson River as a proportion of the predicted Williamson River volume from today through September 30. Said another way, it is yesterday’s Williamson River volume as a proportion of the expected volume to come.

“Fill_rate_ratio_spring” is a proportion expressing the relative progress of filling UKL by May 31.

“EWA_River” is the EWA determined on the 1st of each month from March through June.

“EWA_reserve” is the portion of the EWA reserved from use during the spring and subsequently used June through September.

“EWAuseddv_{-1}” is a cumulative variable beginning March 1 and adding the daily increment of flow released as EWA.

“C1_EXC_{-1}” is yesterday’s flood prevention releases.

“$\text{Net\_LK\_accrete}_{-1}$” is yesterday’s net accretions between Link River Dam and Keno Dam.

Flow in the Williamson River is the primary hydrologic indicator used to calculate a release target for Link River Dam during the spring. The initial calculated Link River Dam release target is modified based on the (1) fill rate ratio for UKL, (2) volume of EWA reserved for summer use, (3) spill from UKL for flood prevention, and (4) accretions to the Klamath River between Link River Dam and IGD.

In all but extreme dry years, UKL is filling and continues to fill as the irrigation season begins, even as distribution of water to the Project and to the Klamath River increases. The Fill_rate_ratio_spring variable is designed to keep UKL on an appropriate trajectory to fill as hydrologic conditions change during the spring. The Fill_rate_ratio_spring reduces Link River Dam releases for EWA early in the irrigation season as UKL is filling. The influence of the Fill_rate_ratio_spring variable decreases steadily throughout the spring as UKL fills. Reducing releases somewhat on the ascending limb of the UKL hydrograph functions to increase releases on the descending limb of the hydrograph, which coincides with the timing of more intensive upper Klamath Basin non-Project agricultural diversions that likely influence Williamson River flows in the spring/summer. Therefore, the Fill_rate_ratio_spring simultaneously functions to fill UKL and redistribute EWA releases to produce a more “normal-shaped” hydrograph in the Klamath River later in the year.

During March through May, the EWA_reserve volume is subtracted from EWA_River, to retain the reserve volume for subsequent use during the summer. However, no water is reserved when UKL is spilling, or when releases at Link River Dam are made to meet minimum target flows at IGD.

$$\begin{aligned}\textbf{June Link River Dam release} \\ &= \text{Will\_prop\_cum} * (\text{EWA\_River} - 0.5 \\ &\quad * \text{EWA\_reserve} - \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

In June, UKL elevations are typically declining and the Fill_rate_ratio_spring variable is dropped. The latter days of June also often mark the transition into the base flow period; therefore, half of the EWA_reserve volume is subtracted from EWA_River instead of subtracting the full volume.

$$\begin{aligned}\textbf{July, August, and September Link River Dam release} \\ &= \min\left(\text{Link\_release\_forIGmax}, \frac{\text{EWA\_remain\_JulSep}}{\text{daysinmonth}}\right)\end{aligned}$$

“IG_max” is the maximum flow target at IGD during July through September.

“Link_release_forIGmax” is the approximate release from Link River Dam necessary to produce the “IG_max” flow at IGD.

“EWA_remain_JulSep" is the total remaining EWA for July through September.

During July through September, Link River Dam releases are the lesser of (1) the maximum IGD flow target (Table 4.10), or (2) the average daily release for the remaining EWA volume. The rationale for selecting the lesser of two options is that when IGD flow targets would be exceeded, that water is not released, but is banked until October and November when it will have greater ecosystem benefits.

Table 4.10. July, August, and September Iron Gate Dam maximum flow targets.

EWA Volume (acre-feet)	July(cfs)	August (cfs)	September (cfs)
320,000	1,000 (28.3 m^3/sec)	1,050 (29.7 m^3/sec)	1,100 (31.2 m^3/sec)
1,500,000	1,500 (42.5 m^3/sec)	1,250 (35.4 m^3/sec)	1,350 (38.2 m^3/sec)
> 1,500,000	1,500 (42.5 m^3/sec)	1,250 (35.4 m^3/sec)	1,350 (38.2 m^3/sec)
Intermediate values are obtained by linear interpolation			

4.2.3.2.4 Flood Prevention and Environmental Water Account Management

Flood releases from Link River Dam occur any time UKL elevations exceed, or appear likely to exceed, elevations that put UKL levees at risk of failure or being overtopped. During the irrigation season, the majority of these releases occurs in March, April, and May in average to wet years. However, flood prevention releases can occur later in the water year, and may also occur in drier years under certain conditions such as rain on snow events. Flood prevention releases in the spring/summer are counted against the EWA. In some cases, flood prevention releases can be so large and account for such a high proportion of the total EWA that the remaining EWA is not adequate to provide acceptable habitat in the Klamath River for listed species for the remainder of the spring/summer season. To protect against this scenario, the EWA is increased when flood prevention releases from Link River Dam exceed 22 percent of the total EWA by June 1. The volume of remaining EWA each month is determined based on the following:

1. If the total flood prevention releases that have occurred by June 1 exceed 22 percent of the June 1 EWA calculation, the remaining EWA is reset to 25 percent of the total June 1 EWA.

2. If the total flood prevention releases that have occurred by July 1 exceed 22 percent of the June 1 EWA calculation, the remaining EWA is reset to 18 percent of the total June 1 EWA.

3. If the total flood prevention releases that have occurred by August 1 exceed 22 percent of the June 1 EWA calculation, the remaining EWA is reset to 13 percent of the total June 1 EWA.

4. If the total flood prevention releases that have occurred by September 1 exceed 22 percent of the June 1 EWA calculation, the remaining EWA is reset to 7 percent of the total June 1 EWA.

The formulaic approach for EWA distribution using Williamson River as a hydrologic indicator is designed to consider and account for key ecological objectives for UKL and the Klamath River. Although expected to be rare, there may be circumstances or emergency situations where it is desirable or necessary to deviate from this approach. In addition, there may be specific ecological objectives that water resource managers need to address that can only be achieved by deviating from the EWA distribution methodology. Deviations are most likely to be alterations in the magnitude or duration of flow to address urgent ecological concerns such as mitigating fish disease, die off, entrainment, dispersal, or migration. Water quality concerns or other ecological issues that arise during spring/summer may also prompt deviation from the formulaic distribution system. Any time a deviation from this approach is proposed, the process detailed in Section 4.3.4 (*Implementing Environmental Water Account Management*) of Reclamation's BA, will be followed. As part of the Environmental Water Management process and protocol, deviations from the formulaic approach to EWA distribution will be evaluated to ensure the action will not result in effects to listed species greater than those analyzed in this BiOp.

During real-time operations of the proposed action, Reclamation may identify the need to deviate from the formulaic calculation of IGD releases due to safety or operational constraints. If the deviation under real-time operations is expected to result in lower magnitude peak flows below IGD than calculated under the proposed action, Reclamation will ensure that the calculated daily average peak flow magnitude is achieved. If there is uncertainty associated with the daily peak flow magnitude at IGD, Reclamation will implement flows that are reasonably certain to exceed the calculated peak flow at IGD under the proposed action (Reclamation 2013b).

Upon conclusion of a peak flow event, Reclamation will evaluate whether deviating from the formulaic calculations resulted in the release of additional water from UKL to achieve the calculated peak flow at IGD. If additional water is released from UKL in the October through February period to achieve a calculated peak flow at IGD (resulting in a lower end of February UKL elevation), the March 1st UKL Supply will be calculated as if the additional volume of water remained in UKL, and this volume of water will be subtracted from the Project Supply. If additional water is released from UKL to achieve a calculated peak flow at IGD in the March through September period, the additional volume of water released will be counted against the Project Supply. However, if the additional water release occurs prior to June 1st, and the UKL Supply recalculation increases on May 1st or June 1st, the Project Supply will increase accordingly up to the amount of the additional water release, prior to increasing the EWA (Reclamation 2013b).

4.2.3.2.5 Yurok Tribal Boat Dance Ceremony

As a deviation from the EWA implementation, Reclamation proposes to increase flows to the Klamath River in late August or early September to support the Yurok Tribal Boat Dance Ceremony. Typically, the Yurok Tribe has requested increased flows at IGD on even calendar years to ensure adequate flow and depth to support boat dance activities. The volume of water required for the ceremony is estimated to be between 2,000 and 4,000 acre-feet depending on real-time hydrologic conditions. The volume of water required to increase IGD releases for the purpose of the boat dance ceremonies will not affect the EWA volume.

4.2.3.2.6 Project Supply

The Project Supply is calculated monthly from March through June, based on available UKL Supply as follows:

Project Supply = [UKL Supply] – [EWA]

The Project Supply can increase or decrease in April relative to the initial calculation on March 1 based on changes to available UKL Supply; however, the April 1 calculation establishes the minimum Project Supply for the water year. The May and June updates accommodate the change in forecast and observed UKL net inflows by adjusting the EWA and UKL Reserve volumes. The Project Supply also may be adjusted in May and June, but the adjustments may not reduce the Project Supply below the volume calculated on April 1. The June Project Supply calculation is the final Project Supply determination of the water year, and is the volume of water available for delivery to the west side of the Project and Lower Klamath NWR from UKL. The real-time distribution of the Project Supply will be based on current hydrologic conditions.

In extreme dry years, the UKL Supply may decline after April even as the EWA is at its minimum of 320,000 acre-feet. This occurred once in the POR, based on the model study. If this scenario occurs during the life of this proposed action, the Project Supply will remain at the volume calculated in April, and the decline in supply will come out of UKL. If it appears the reduction in storage will result in the UKL elevation approaching the lowest modeled one-day elevation (4,137.72 feet [1,261.5 meters]), Reclamation will adjust deliveries to the Project to prevent the UKL elevation from dropping below 4,137.72 feet (1,261.5 meters).

As described in Reclamation’s clarification letter dated May 29, 2013, NMFS suggested the proposed minimum Klamath River flows for the months of April, May, and June would pose unacceptable risk to coho salmon and its designated critical habitat. To reduce this risk, Reclamation proposed to revise the minimum daily average flows at the U.S. Geological Survey gage no. 11516530, Klamath River below IGD, to 1,325 cfs, 1,175 cfs, and 1,025 cfs for April, May, and June, respectively. In some years, a larger EWA volume is required to maintain the revised minimum daily average flows at IGD during April, May, and June than currently described in Reclamation’s BA. As a result, Reclamation reviewed the model results with the revised IGD minimum daily flows to assess the effects to UKL elevations. Reclamation found that the increased releases at Link River Dam to meet the revised minimum daily average flows at IGD affected UKL elevations in some years. Reclamation proposes to delay the start of Project irrigation deliveries from UKL or limit discretionary diversions from the lake by an amount equal to the increased releases at Link River Dam to avoid impacting UKL elevations and ESA-listed suckers beyond those described in Reclamation’s BA (Reclamation 2013b).

The Project Supply, as defined, does not include contributing flow from the Lost River system. Therefore, any flows (primarily return flows in the west side of the Project) originating from the Lost River system that are diverted for irrigation do not count against the Project Supply from UKL. Flows from the Lost River diverted by the Project will be evaluated on a daily basis and subtracted from the total Project diversion to compute the daily Project Supply use. Any portion of contributing flows from the Lost River system not used for Project purposes will be routed to the Klamath River and considered part of the Keno Reservoir accretions, which do not count against the EWA.

Historical Project deliveries from UKL and Lost River return flows were analyzed by Reclamation for the POR. The analysis indicates a Project Supply of 390,000 acre-feet plus return flows from the Lost River system always exceeded the historical irrigation demand. Therefore, a Project Supply of 390,000 acre-feet from UKL is a full irrigation supply for the Project when combined with Lost River return flows. The Project Supply is capped at 390,000 acre-feet when the Project Supply calculation results in values greater than 390,000 acre-feet, based on model simulations conducted during development of the proposed action. Graphical representations of the relationship modeled between EWA, Project Supply, and UKL Reserve, based on the UKL supply, are presented in Figure 4.1 and Figure 4.2.

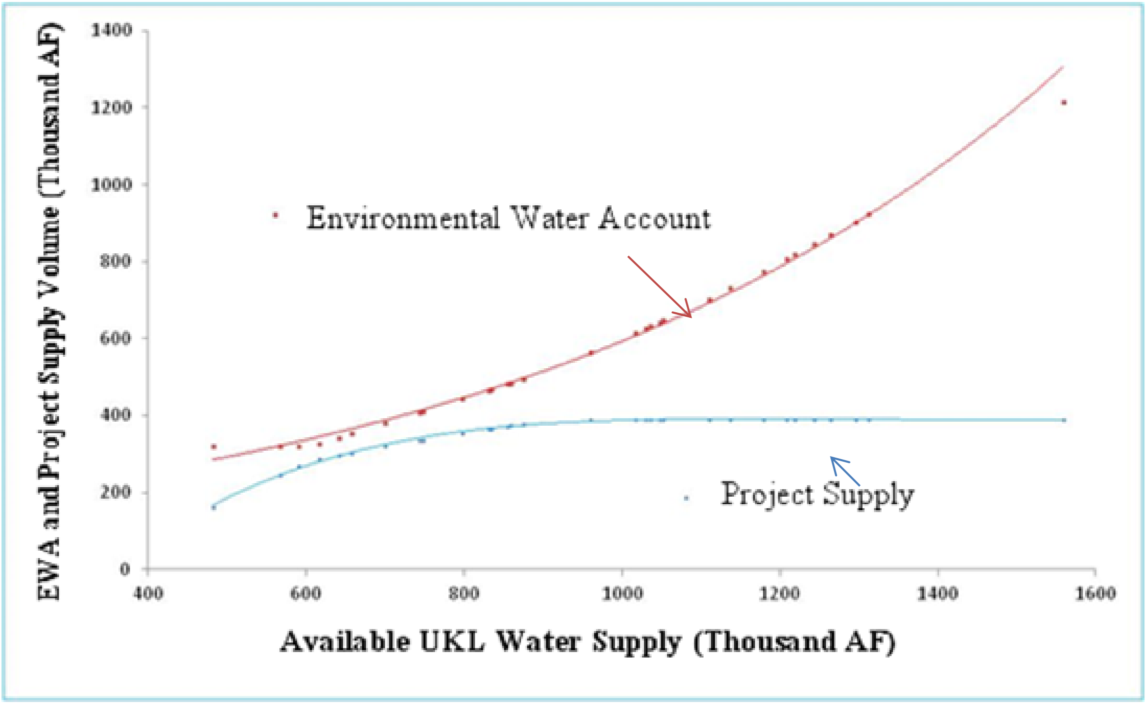


Figure 4.1. Modeled EWA and Project Supply, based on UKL supply (Reclamation 2012).

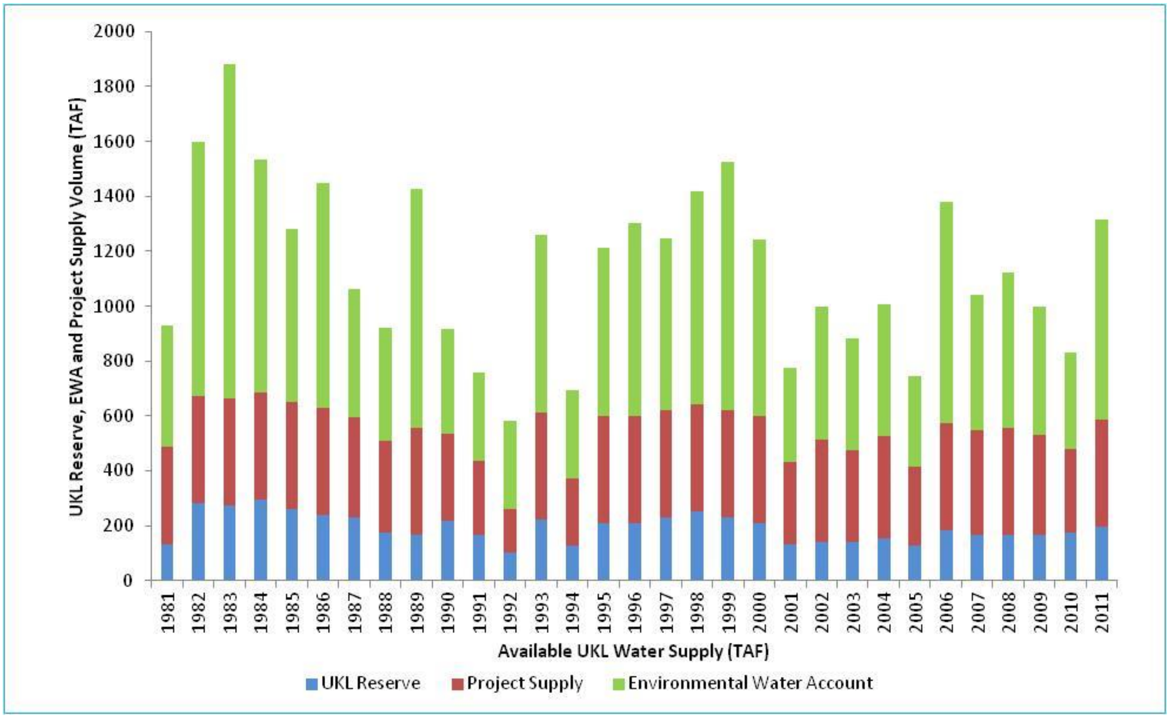


Figure 4.2. Modeled UKL Reserve, EWA, and Project Supply based on available UKL water supply (Reclamation 2012).

4.2.3.2.7 Lower Klamath National Wildlife Refuge Supply

Lower Klamath National Wildlife Refuge receives water from the Klamath River via Ady Canal and from Tule Lake Sump 1A via Pumping Plant D. The pattern of deliveries to Lower Klamath NWR has changed in recent years because of substantial increases in power costs associated with pumping at Plant D. The cost increases have caused Tulelake Irrigation District to minimize pumping through Plant D, requiring Lower Klamath NWR to become increasingly dependent on water from the Klamath River. In the context of this proposed action, Lower Klamath NWR deliveries refer **only** to water provided from the Klamath River through Ady Canal.

Water for Lower Klamath NWR may be delivered by two methods during the spring/summer. The first method provides non-Project Supply and non-EWA water out of Keno Reservoir accretions or UKL storage. The second method uses excess Project Supply, if there is an excess. Lower Klamath NWR deliveries are contingent upon available water supply, and deliveries are not made when Project Supply shortages exist.

The KBPM delivers water that is **not** part of the Project Supply to Lower Klamath NWR from June through November when the Project Supply is 390,000 acre-feet and the elevation of UKL exceeds the threshold values listed in Table 4.11. Lower Klamath NWR may receive up to the maximum potential delivery volume (developed by Reclamation, based on historical data) shown in Table 4.11. The comparison to threshold elevations is made daily; therefore, water is delivered to Lower Klamath NWR daily on a prorated basis for each monthly maximum potential delivery target.

Table 4.11. Monthly maximum Lower Klamath NWR delivery and Upper Klamath Lake elevation thresholds.

Month	Maximum Potential Delivery (acre-feet)	Upper Klamath Lake Threshold ft (m)
June	5,940	4,142.50 (1,262.63)
July	6,930	4,141.50 (1,262.33)
August	5,904	4,140.50 (1,262.02)
September	17,160	4,139.50 (1,261.72)
October	15,180	4,139.00 (1,261.57)
November	11,530	4,139.50 (1,261.72)

Water that ***is*** part of the Project Supply may be provided to the Lower Klamath NWR from August through November if Reclamation determines the Project is not expected to use its entire supply. If the Project Supply is less than 390,000 acre-feet, or the UKL elevation is less than the thresholds shown in Table 4.11, water may be only delivered to the Lower Klamath NWR based on a percentage of the remaining Project Supply. The percentages range up to 8 percent of remaining Project Supply in August, 14 percent in September, and 28 percent in October and November.

4.2.3.2.8 Summary of Select Model Output

Output for a variety of parameters for UKL and flows at IGD is provided in Table 4.12. Tables of weekly UKL elevations and weekly average flow in the Klamath River below Link River Dam, Keno Dam, and Iron Gate Dam are included in Appendix B. Substantial additional output regarding the proposed action is presented in Reclamation's final BA (Reclamation 2012).

Table 4.12. Proposed action model summary output results.

Year	June 1 EWA Volume (acre-feet)	End of September UKL Elevation (feet)	Project Supply from UKL (Mar-Nov Determined June 1) (acre-feet)	Total Project Deliveries from UKL (Mar–Nov) (acre-feet	Total LKNWR Deliveries by Water Year (Oct–Sept) (acre-feet)
1981	419,200	4,138.23 (1,261.33 m)	353,500	349,400	4,200
1982	824,300	4,140.36 (1,261.98 m)	390,000	289,500	40,100
1983	1,100,200	4,140.26 (1,261.95 m)	390,000	280,400	64,700
1984	974,800	4,140.57 (1,262.05 m)	390,000	300,800	72,600
1985	631,800	4,140.06 (1,261.89 m)	390,000	352,000	68,000
1986	744,800	4,139.76	390,000	354,600	45,100

		(1,261.80 m)			
1987	443,100	4,139.71 (1,261.78 m)	365,600	364,100	21,200
1988	411,700	4,138.90 (1,261.54 m)	337,000	329,200	9,400
1989	845,500	4,138.77 (1,261.50 m)	390,000	351,300	28,900
1990	385,800	4,139.52 (1,261.73 m)	322,800	321,900	15,200
1991	320,000	4,138.85 (1,261.52 m)	281,900	274,500	100
1992	320,000	4,137.82 (1,261.21 m)	161,300	146,600	200
1993	701,800	4,139.60 (1,261.75 m)	390,000	328,200	34,900
1994	320,000	4,138.26 (1,261.34 m)	263,300	249,400	24,800
1995	622,500	4,139.41 (1,261.69 m)	390,000	306,600	34,400
1996	734,700	4,139.37 (1,261.68 m)	390,000	348,300	53,200
1997	573,200	4,139.69 (1,261.78 m)	390,000	380,100	61,900
1998	929,900	4,140.03 (1,261.88 m)	390,000	282,700	56,800
1999	900,200	4,139.70 (1,261.78 m)	390,000	369,300	57,000
2000	643,000	4,139.36 (1,261.68 m)	390,000	371,200	42,500
2001	363,800	4,138.27 (1,261.35 m)	310,100	305,200	12,700
2002	428,700	4,138.40 (1,261.38 m)	373,700	371,700	5,800
2003	442,900	4,138.46 (1,261.40 m)	353,400	339,900	3,300
2004	430,800	4,138.58 (1,261.44 m)	372,500	369,000	3,900
2005	393,000	4,138.25 (1,261.34 m)	326,800	319,100	5,800
2006	819,000	4,139.00 (1,261.57 m)	390,000	342,200	27,300
2007	496,000	4,138.86 (1,261.53 m)	379,400	374,400	26,800
2008	549,100	4,138.78 (1,261.50 m)	390,000	347,400	20,400
2009	465,100	4,138.84 (1,261.52 m)	364,700	352,600	22,200
2010	345,900	4,138.93 (1,261.55 m)	303,600	296,700	3,700
2011	745,300	4,139.20 (1,261.63 m)	390,000	310,200	34,000

4.2.4 Ramp-Down Rates at Iron Gate Dam

Ramping rates on the receding limb of a hydrograph limit the rate at which flow declines following a higher flow rate or large volume release. Reclamation proposes a ramp down rate schedule at IGD that varies by flow magnitude. IGD is owned and operated by PacifiCorp, and ramp down rates will be implemented by PacifiCorp as part of IGD operations. Reclamation will coordinate with PacifiCorp, as appropriate, on implementation of the ramp down rates. Reclamation proposes the following ramp down rates at IGD:

- Flow at IGD greater than 3,000 cfs (85.0 m^3/sec): Ramp down rates will follow the combined 3-day moving average of net inflows into UKL and accretions between Link River Dam and IGD. The ramp down rates will be implemented to the extent practicable, based on physical constraints at PacifiCorp facilities and safety of workers and the public. The 3-day moving average allows for ramp rates to mimic natural hydrology while mitigating extreme variability that can occur with daily changes in net inflow calculations due to gage error and/or high wind events. The ramp down rate schedule also ensures UKL is not drawn down to accommodate rapid, transient declines in inflow and/or accretions lasting less than one day. Reclamation calculates inflow to UKL on a daily basis. In the event of gage failure or instability caused by weather conditions, Reclamation will use professional judgment to estimate changes in net inflow.
- Flow at IGD between 1,751 cfs and 3,000 cfs (49.6 and 85.0 m^3/sec): Decreases in flow of 300 cfs (8.5 m^3/sec) or less per 24-hour period, and no greater than 125 cfs (88.5 m^3/sec) per 4-hour period.
- Flow at IGD less than or equal to 1,750 cfs (49.6 m^3/sec): Decreases in flow of 150 cfs (4.3 m^3/sec) or less per 24-hour period, and no more than 50 cfs (1.4 m^3/sec) per 2-hour period.

PacifiCorp's hydroelectric operations limit the ability to manage changes in releases from IGD at a fine resolution, particularly when flow is greater than 3,000 cfs (85.0 m^3/sec). In addition, facility control emergencies may arise that warrant the exceedance of the proposed ramp down rates. Therefore, Reclamation recognizes that minor variations in ramp rates will occur. All ramping rates proposed above are targets, and are not intended to be strict maximum ramping rates. Reclamation expects substantial exceedance of the proposed ramp rates to occur infrequently as a result of facility control limitations or other emergency situations.

4.2.5 Tule Lake Sump 1A Operations

Tule Lake Sump 1A (Tule Lake) receives water from Project facilities. A specific volume of water is not earmarked for delivery to Tule Lake because historically it has received an adequate supply from agricultural runoff and drainage. Excess water in Tule Lake is controlled by pumping to the Lower Klamath NWR through Pumping Plant D.

The proposed minimum elevations for Tule Lake are shown in Table 4.13. The availability of water and Tulelake Irrigation District return flows determine the amount of water available for Tule Lake in any one year.

Table 4.13. Proposed minimum Tule Lake Sump 1A elevations (Reclamation datum).

Time Period	Proposed Minimum Elevation
April 1 through September 30	4,034.60 ft (1,229.75 m)
October 1 through March 31	4,034.00 ft (1,229.56 m)

If the Project receives deliveries, then Reclamation will maintain these minimums in Sump 1A.

4.2.6 Environmental Water Account Management

The broad operational priorities for the Upper Klamath Basin are: (1) ESA compliance, (2) meeting contractual obligations to Klamath Project irrigators, and (3) providing water to the Lower Klamath NWR when ESA and contractual obligations have been met. These operational priorities mandate active water management throughout the year in accordance with the operational descriptions above. Specific EWA management is a critical element of the overall water management mandates. EWA management must meet or exceed IGD target flows, meet or exceed UKL recommended elevations, and provide flow variability in the Klamath River and variability in UKL levels that mimic the natural flow regime and are representative of hydrologic conditions.

The purpose of Environmental Water Management is to effectively and efficiently use a broad range of technical expertise to implement EWA use under the coordination of a EWA Manager (Manager). Water management is proposed to meet ecological objectives for coho salmon (and other species) in the Klamath River while considering the ecological needs of listed suckers in UKL.

The Manager will coordinate with a Flow Account Scheduling Technical Advisory (FASTA) Team to integrate and synthesize technical recommendations from the FASTA Team members. The primary role of the Manager is to coordinate with the FASTA Team to determine how to manage and optimize the EWA in real-time operations to best meet the needs of coho salmon in the Klamath River while balancing the needs of listed suckers in UKL. The Manager also will coordinate with PacifiCorp regarding required flows at Link River Dam and IGD. The Manager will be employed by Reclamation, and is responsible for providing information and recommendations to Reclamation’s Klamath Basin Area Manager.

4.2.6.1 EWA Management Process

The Manager and FASTA Team will use January and February NRCS 50 percent exceedance forecasts for UKL net inflow and other relevant hydrologic and meteorological data to evaluate probable EWA volumes and distribution for the spring/summer. As the irrigation season progresses and EWA volumes are updated between March and June, the Manager and FASTA Team will track distribution of EWA in conjunction with UKL elevations and Project Supply use in accordance with the operational procedures described in Section 4.2.3.

Under certain circumstances, deviating from the EWA formulaic distribution may be desirable or necessary. Although expected to be rare, there may be circumstances, such as high disease rates or dangerously high water temperatures in the Klamath River below IGD, or flooding from rain-on-snow events causing emergency situations for UKL infrastructure, where it is desirable or necessary to deviate from the formulaic EWA distribution approach. In addition, there may be specific ecological objectives that water resource managers need to address that can only be achieved by deviating from the EWA distribution methodology. Deviations are most likely to be alterations in the magnitude or duration of flow to address urgent ecological concerns, such as mitigating fish disease, die off, entrainment, dispersal, or migration. Water quality concerns or other ecological issues that arise during spring/summer may also prompt deviation from the formulaic EWA distribution system.

Any time a deviation from the formulaic approach is proposed, the process detailed in Section 4.3.4 (Implementing Environmental Water Account Management) of Reclamation's BA will be followed. Any recommended deviation from the EWA distribution methodology must be shown to result in improved ecological conditions for listed species, and cannot cause an adverse effect to listed species or critical habitat that was not considered by the USFWS and the NMFS for this proposed action. There are many factors to be considered when developing EWA distribution regimes that deviate from the formulaic approach. Reclamation is coordinating with stakeholders to develop Flow Scheduling Guidelines that will provide guidance for implementing EWA Management to optimize the ecological benefits to aquatic species. Reclamation proposes to develop and adopt the Flow Scheduling Guidelines and formal structure for EWA management in coordination with the NMFS, the USFWS, and appropriate stakeholders within 1 year of implementing the proposed action.

Meanwhile, Reclamation proposes the following process for deviating from the formulaic distribution of the EWA for the evaluation of near real-time data on disease risks to coho salmon. The process will be included as a key objective in the Flow Scheduling Guidelines document for consideration by the Flow Account Scheduling Technical Advisory (FASTA) Team, described in Section 4.3.4 of Reclamation's BA. In the event that disease risks are at or above threshold levels and EWA volumes indicate surplus water is available, Reclamation will deviate from the formulaic distribution of EWA and increase Link River releases to reduce actinospore concentrations downstream of IGD.

Specifically, Reclamation will:

> (1) Continue the ongoing water quality program collecting mainstem Klamath River water samples of actinospore concentrations and laboratory analyses will continue through the action period. Reclamation, in coordination with NMFS and disease researchers, will evaluate the program efficiency and determine if there are opportunities to accelerate the timeline to evaluate water quality samples such that Reclamation and NMFS will receive as near as real-time results on actinospore concentration as feasible.

> Subject to available funding, Reclamation will also support efforts to create efficiencies to the water quality program;
> (2) propose a flow increase for the Klamath River downstream of IGD to the FASTA Team, in coordination with NMFS and the USFWS, to dilute actinospore concentrations within 24 hours of receiving information that disease thresholds have been met. Currently, the disease thresholds for the mainstem Klamath River immediately upstream of Beaver Creek consist of actinospore concentrations of at least 5 spores/L of genotype II and an average daily water temperature of at least 16 °C. The magnitude and duration of the flow increase will be developed with consideration to (a) an effective dilution factor, (b) surplus EWA volume, and (c) potential effects to UKL and ESA-listed suckers. Within 24 hours of consultation with the FASTA Team, Reclamation will implement the flow increase at Link River, if appropriate based on discussions between FASTA and the Services; and
> (3) coordinate with the Services and disease researchers to update the thresholds listed above in item 2 as new disease-related information becomes available.

A deviation from the formulaic distribution of EWA could result in short term effects to UKL elevations, but will not result in changes to the end of September UKL elevation as no increase to EWA will occur as a result of this change in EWA distribution. In the event that a deviation from the formulaic distribution of EWA is expected to result in effects to UKL elevations, the FASTA Team will closely coordinate closely with the USFWS to ensure that the deviation will not create adverse effects greater than analyzed by USFWS during this consultation.

4.2.6.2 EWA, Project Supply, and Refuge Water Accounting

The Manager will perform weekly in-season accounting and reporting of EWA usage as well as remaining EWA, Project deliveries, remaining Project Supply, UKL elevation, refuge deliveries, and remaining refuge allotment. This weekly accounting will track EWA usage and ensure that the EWA is used according to the EWA distribution formula. Also, the weekly accounting may identify if too much EWA water is being used early in the season, which may result in an EWA shortage and low IGD base flows late in the season.

4.3 Element Three

> *Perform the operation and maintenance activities necessary to maintain Klamath Project facilities to ensure proper long-term function and operation.*

Operation and maintenance (O&M) activities related to the proposed action are described in this section. These activities have been ongoing during the history of the Project, and have been implicitly included in previous consultations with the USFWS on Project operations. No new O&M activities are proposed; rather, ongoing activities are described to provide a more complete understanding of Project maintenance activities so the potential effects of these activities on listed species can be analyzed. Reclamation has attempted to include the activities necessary to maintain Project facilities and ensure proper long-term functioning and operation. Reclamation recognizes this is not an exhaustive list and there may be items omitted inadvertently. However, Reclamation believes that if any activities were omitted, they are similar in scope and will not cause an effect to listed species or critical habitat outside the effects analyzed for the activities described herein.

O&M activities are carried out either by Reclamation or the appropriate irrigation district, based on whether the facility is a reserved or transferred work, respectively. Operation of non-Federal facilities by non-Federal parties is not included as part of this proposed action.

4.3.1 Dams and Reservoirs

4.3.1.1 Exercising of Dam Gates

The gates at Gerber, Clear Lake, Link River, and Lost River Diversion Dams, and the A Canal, Ady Canal, and Link River Dam headgates are exercised twice annually, before and after each irrigation season, to be sure they operate properly. The gates are usually exercised between March 1 to April 15, and October 15 to November 30, and potentially in conjunction with any emergency or unscheduled repairs. Exercising gates takes from 10 to 30 minutes depending on the facility. Associated maintenance activities performed when exercising gates at specific facilities are as follows:

1. Link River Dam is operated by PacifiCorp, and scheduled exercising of the gates does not occur because the dam is operated continuously. As such, gates are considered exercised whenever full travel of the gates is achieved. A review of O&M inspection is performed every 6 years.

2. Clear Lake Dam activities include exercising both the emergency gate and the operation gate. Depending on reservoir elevations and conditions, water may be discharged to allow for sediment flushing at the dam face. Flushing requires flows less than or equal to 200 cfs (5.7 m^3/sec) for approximately 30 minutes. Maintenance occurs once a year, generally in March or April.

4.3.1.2 Dam Facilities

Dam conduits associated with irrigation facilities typically have an average lifespan of 30 years, and are replaced on an as-needed basis. O&M activities include land-based observation and deployment of divers to determine if replacement is necessary. Divers are deployed at Clear Lake, Gerber Reservoir, and Link River Dam every 6 years prior to the Comprehensive Facilities Review for inspection of underwater facilities. If replacement is necessary, Reclamation will evaluate the potential effects to federally listed species and determine if additional ESA consultation is required.

Design Operation Criteria, which outlines O&M guidelines for facilities maintenance, is required at Link River Dam, Clear Lake Dam, Gerber Dam, and the Lost River Diversion Channel gates. The Design Operation Criteria is used to develop Standard Operating Procedures for Reclamation facilities. The Standard Operating Procedures outline the maintenance procedures, requirements, and schedule. The activities address the structural, mechanical, and electrical concerns at each facility. Some of the components of facilities that require maintenance are typically reviewed outside of the irrigation season and include, but are not limited to, the following:

- Trash racks—Maintained when necessary. Trash racks are cleaned and debris removed daily or as needed. Maintenance is specific to each pump, as individual pumps may or may not run year round. Cleaning can take from 1 to 8 hours.
- Concrete repair occurs frequently and as needed. The time necessary to complete repairs to concrete depends on the size and type of repair needed.
- Gate removal and repair or replacement is conducted as needed. Inspections of gates occur during the dive inspection prior to the Comprehensive Facilities Review every 6 years. Gates are visually monitored on a continuous basis.

4.3.1.3 Gage and Stilling Well Maintenance

Gage maintenance is required at various project facilities to ensure accurate measurement of flow. Gage maintenance generally includes sediment removal from the stilling well, replacement of faulty equipment, modification, and/or relocation of structural components, and/or full replacement of the structure, as necessary. Reclamation estimates that one structure is replaced every 5 to 10 years. Stilling wells are cleaned once a year during the irrigation season.

4.3.1.4 Boat Ramps

Boat ramps and associated access areas at all reservoirs are maintained, as necessary, to provide access to Project facilities throughout the year. Gravel boat ramps are maintained on an approximately 5-year cycle. Concrete boat ramps are maintained on an approximately 10-year cycle. Maintenance may include grading, geotextile fabric placement, and gravel augmentation, or concrete placement.

4.3.1.5 Canals, Laterals, and Drains

An inspection of canals, laterals, and drains occurs on an annual basis, or as needed. All canals, laterals, and drains are either dewatered after the irrigation season or have the water lowered for inspection and maintenance every 6 years as required as part of the review of O&M. More frequent maintenance is on a case-by-case basis, as needed. Inspection includes examining the abutments, foundations, other concrete, mechanical facilities, pipes, and gates.

Historically, dewatering of canals, laterals, and drains has included biological monitoring and salvage of listed species, as needed. This practice will continue under the proposed action.

Canals, laterals, and drains are also cleaned to remove debris, sediment, and vegetation on a timeline ranging from annually to every 20 years. Animal burrows that may affect operations or facility structures are dug out, then refilled and compacted. Trees that may affect operations or facility structures, or present a safety hazard, are removed and the ground returned to as close to previous conditions as practicable.

All gates, valves, and equipment associated with the facilities are exercised once or twice annually, before and/or after the irrigation season. Pipes located on dams or in reservoirs have an average lifespan of 30 years, and are replaced when needed. Reclamation replaces approximately 10 sections of pipe a year, and prefers to perform this activity when canals are dry. Associated maintenance activities performed when exercising gates at specific canals are described as follows:

1. The A Canal has six headgates that are maintained. The A Canal headgates are only operated and exercised when fish screens are in place. However, if the fish screens fail, the A Canal will remain operational until the screen is repaired or replaced. Screen failure occurs under certain circumstances, such as when water pressure is too high, and the screens break away so as not to ruin the screen or other infrastructure. Fish screens typically fail once or twice a year during normal operation, and Klamath Irrigation District is notified by means of an alarm. Fish screens are repaired as quickly as practicable.

2. The A Canal headgates are typically exercised in February or March, and in October or November when bulkheads are in place and the A Canal is drained and empty.

3. The Lost River Diversion Channel diagonal gates and banks are scheduled for inspection every 6 years. Inspection is conducted during the winter, which requires drawdown of the Lost River Diversion Channel. However, drawdown of the Lost River Diversion Channel leaves sufficient water to ensure that fish are not stranded. The appropriate water levels are coordinated between O&M staff and Reclamation fish biologists. Biological monitoring is incorporated to ensure flows are adequate for fish protection.

4. The Ady Canal headgates are exercised annually, typically between July and the end of September.

4.3.1.6 Fish Screen Maintenance

The A Canal fish screens have automatic cleaners. Cleaning is triggered by timing or a head difference on either side of the screen. Automatic cleaner timing intervals are typically set at 12 hours, but may be changed as conditions warrant.

Fish screens at the Clear Lake headworks are cleaned before the irrigation season and when 6 to 12 inches (in) (15 to 30 centimeters (cm)) of head differential between forebays 1 and 2 is observed. The frequency of cleaning is dictated by water quality and lake elevation, and varies from year to year. For example, in 2009 the screen was cleaned every other day from late June through September. In 2011 cleaning was not required during the irrigation season. An extra set of fish screens is used while the working fish screens are cleaned to prevent fish passing the headworks. Cleaning the fish screens at Clear Lake may take up to 10 hours. Fish screens are not used during flood releases when Clear Lake elevations are greater than or equal to 4,543.00 ft (1,384.71 m), but the maximum lake elevation observed during the POR for this water body (4,539.55) is nearly 3.5 feet (1.1 m) below this elevation.

4.3.1.7 Fish Ladder Maintenance

Link River Dam fish ladder O&M includes exercising both the headgate and the attraction flow gate. Gates are exercised twice a year in February or March and in November or December. Exercising the gates typically takes approximately 15 minutes. This activity includes monitoring by Reclamation biologists.

4.3.1.8 Pumping Facilities

All pumping plants are monitored yearly by visual inspection. Dive inspections occur every 6 years according to the review of O&M inspection. This activity includes dewatering of the adjacent facility and installation of coffer dams. Dive inspections and dewatering of the facilities typically occurs in August to December. Biological monitoring occurs daily during dewatering, and will be continued in this proposed action to ensure the protection of fish.

All pumps are greased, cleaned, exercised, and oil levels checked monthly if they are not in regular use. Pumps are greased and oiled according to the manufacturer's specifications. Excess grease and oil is removed. When oil is changed, oil spill kits are available and used as necessary. Pumps used for irrigation are maintained daily during the irrigation season. Drainage pumps are maintained and operated on a daily basis throughout the year.

4.4 Conservation Measures

Conservation measures are actions to benefit or promote the recovery of listed species that are included by Reclamation as an integral part of the proposed action. These actions will be taken by Reclamation, and serve to minimize or compensate for project effects on the species under review. These may include actions taken prior to initiation of consultation, or actions that Reclamation has committed to complete in a BA or similar document. The proposed conservation measures assist Reclamation in best meeting the requirements under section 7 of ESA by (1) utilizing programs in furtherance of the purposes of the ESA, and (2) avoiding actions that are likely to jeopardize the continued existence of listed species or are likely to result in the destruction or adverse modification of critical habitat.

4.4.1 Canal Salvage

Canals, laterals, and drains are dewatered at the end of irrigation season. This activity includes capture and relocation (salvage) of suckers from the canal system after dewatering occurs. Reclamation proposes to continue fish salvage in Project canals, in cooperation with the USFWS, consistent with the salvage efforts that have occurred in Project canals since 2005. Reclamation's fish salvage efforts will focus on the A Canal forebay in front of the fish screen, C4 Canal, D1 Canal, and D3 Canal within the Klamath Irrigation District, and J Canal within the Tulelake Irrigation District. Other locations proposed by the USFWS will be considered on a case-by-case basis. Reclamation may also research alternative methods of dewatering canals, laterals, and drains, which could result in less sucker presence within these facilities at the end of the irrigation season. Should Reclamation determine, based on this research, that fish salvage at specific locations is no longer needed or can be modified, Reclamation will coordinate with the USFWS for concurrence.

4.4.2 Captive Propagation Program

Between 2000 and 2012, Reclamation supported various conservation measures within the upper Klamath Basin that have resulted in significant improvements to the environmental baseline (see section 7 below), including screening the A Canal and Geary Canal, removing Chiloquin Dam, providing fish passage at Link River Dam, increasing habitat at the Williamson River Delta Preserve, and seasonally salvaging suckers from canals. However, there are few, if any, additional practicable options for reducing incidental take of suckers by the Project.

Therefore, Reclamation proposes to support captive propagation of the LRS and the SNS for the purpose of increasing the number of second-year juvenile suckers that reach maturity in UKL. Based on the Services' Policy regarding controlled propagation of species listed under the ESA, captive propagation includes "natural or artificial mattings, fertilization of sex cells, transfer of embryos, development of offspring, and grow-out of individuals of the species when the species is intentionally confined or the mating is directly intended by human intervention" (65 FR 56916-56919; September 20, 2000). Ultimately, the function of captive propagation would be to promote survival and recovery of wild sucker populations that suffer losses as a result of Project actions or other threats. Captive propagation is an important part of recovery efforts for listed fish nationwide, including at least three sucker species (June sucker [*Chasmistes liorus*], razorback sucker [*Xyrauchen texanus*], and robust redhorse sucker [*Moxostoma robustum*]).

The USFWS has implemented pilot studies in raising the LRS and the SNS. Sucker larvae were collected from Keno Reservoir and the Williamson River and successfully reared in a series of tanks and holding ponds for approximately 1 year. Based on these studies, several aspects of the LRS and the SNS captive propagation have been assessed and shown to be practicable, including rearing from eggs taken from wild-caught brood stock, rearing from wild-caught larvae, and rearing from wild-caught juveniles salvaged from Project canals. These efforts show that captive propagation of the LRS and the SNS is feasible and flexible, and could be implemented in a variety of ways.

Specifically, Reclamation proposes to provide approximately $800,000 to the USFWS to support captive propagation in fiscal year 2013. Then annually, starting in fiscal year 2014, Reclamation proposes to provide $300,000 to the USFWS to support the captive propagation program. Reclamation's support of the captive propagation program would be for the term of this proposed action (May 31, 2013, through March 31, 2023). These funds will provide for the development of specific captive propagation plans, related research to support effective rearing of the LRS and the SNS, and implementation of efforts to rear and release individuals. Oversight of the propagation project will be provided by the USFWS with input from the Klamath Sucker Recovery Program, in coordination with Reclamation. The program is intended to have a positive effect on the populations of the LRS and the SNS. However, monitoring will determine the actual effectiveness duration of the program. This determination would be made through coordination between Reclamation and the USFWS, where alternative methods of meeting the goals and intent of this conservation measure may be identified.

4.4.3 Recovery Implementation Team Support

The 2013 Revised Recovery Plan for the LRS and the SNS (Plan) outlines a strategy for a Recovery Program (USFWS 2013). This Program will be a coordinated effort among federal, state, tribal, academic, non-profit organizations and other stakeholders that have resources that will be contributed towards recovery actions. The Recovery Program will be administered and implemented through a USFWS led Recovery Implementation Team (RIT) and this team will help ensure that resources available for recovery are used in an effective and efficient manner. The USFWS intends to establish the RIT in 2013 by formally appointing the members. The focus of the RIT will be to develop, review, prioritize, and make recommendations for implementing actions within the context of the Plan. Although the RIT's primary focus will be implementation of the Plan, it is anticipated that the RIT will also serve the purpose of promoting better coordination and collaboration on sucker related activities that are not specifically identified in the Plan, such as requirements of ESA consultations.

Beginning in 2013, Reclamation intends to work with the USFWS toward achieving the goals and objectives of the Plan, which would include dedication of resources determined in coordination between Reclamation and the USFWS and participation on the RIT.

4.4.4 Capture and Transport of LRS and SNS in Lake Ewauna to UKL

Reclamation proposes to coordinate with the USFWS immediately upon receipt of the BiOp to develop a plan to implement a 3-year effort to capture LRS and SNS in Lake Ewauna and release them into UKL. The plan components would include, but are not limited to, timing of efforts, techniques, release locations and associated monitoring efforts, and contingency plans in the case of mortality and would not be implemented until approved by the USFWS. Subsequent years of effort may be needed depending on the number of suckers caught and a determination of the effectiveness of the effort. This determination will be made by the USFWS in coordination with Reclamation.

4.4.5 Investigation of Reduction of Flows at Link River Dam

Reclamation proposes to work with the USFWS, PacifiCorp, and the EWA manager to investigate a reduction of flows at Link River Dam (e.g., investigating the timing and volume and flows, utilizing Tammy Wood's model to predict larval arrival, using real-time data from Fish Evaluation Station [FES] monitoring to index densities of young suckers, etc.) to determine if there are feasible management options to minimize effects of entrainment at Link River Dam on larvae and juvenile LRS and SNS at key times when peak numbers of larvae and/or juvenile are present at the south end of UKL. This conservation measure is not a study or research proposal, but rather an investigation into a water management strategy which will minimize take of the LRS and SNS and Link River Dam. Reclamation will coordinate with the USFWS to develop the methodology for investigating water management strategies related to reducing flows at Link River Dam and obtain approval from the USFWS before implementing this water management strategy.

4.4.6 Klamath River Restoration

In recent years Reclamation has funded efforts to conserve and protect SONCC coho salmon and other anadromous salmonids in the Klamath River Basin. Reclamation provided funding at various levels from 2004 through 2010 under the Klamath Basin Restoration Program (formerly known as the Conservation Implementation Program). Reclamation recognizes there are adverse effects associated with Reclamation's proposed action on the SONCC coho salmon ESU and its designated critical habitat. In an effort to minimize the adverse effects of the proposed action, Reclamation proposes to provide $500,000 annually, subject to the availability of future funding and annual appropriations (Reclamation 2013b) over the period of this proposed action (May 2013 through March 2023), to support restoration activities for SONCC coho salmon and its critical habitat. Restoration will be focused on activities that provide benefits to SONCC coho salmon and their designated critical habitat in the Klamath River Basin that are most likely to be affected by Reclamation's proposed action. The function of such restoration activities will be to promote survival and recovery of the SONCC coho salmon that are adversely affected as a result of the proposed action. Upon receipt of a final BiOp from the NMFS, Reclamation will coordinate with the NMFS to develop a practical approach for administering the SONCC coho conservation program funds.

Habitat restoration projects funded by Reclamation will be designed and implemented consistent with techniques and minimization measures presented in California Department of Fish and Wildlife's (CDFW) *California Salmonid Stream Habitat Restoration Manual, Fourth Edition, Volume II* (*Part IX: Fish Passage Evaluation at Stream Crossings, Part XI: Riparian Habitat Restoration, and Part XII: Fish Passage Design and Implementation*; Flosi et al. 2010, referred to as the Restoration Manual). Restoration activities include, but are not limited to, the following: instream habitat structures and improvements, barrier modification for fish passage, bioengineering and riparian habitat restoration, removal of small dams (permanent and flashboard), creation of off-channel/side channel habitat, developing alternative stock-water supply, tail-water collection ponds, water storage tanks, piping ditches, fish screens, and installing headgates/water measuring devices. More details of these restoration activities and their associated minimization measures are provided in Appendix C. While the restoration funds may be used for restoration activities not listed above (e.g., placement of conservation easements on key habitat areas in the Klamath River basin), only the restoration activities listed above and described in Appendix C are considered in this BiOp.

5 INTERRELATED AND INTERDEPENDENT ACTIONS

Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Interrelated actions are those that are part of a larger action and depend on the larger action for their justification (50 CFR 402.02). The Services have determined there are no interdependent or interrelated actions associated with Reclamation's proposed action considered in this BiOp.

6 INFORMAL CONSULTATION

Reclamation determined that the proposed action may affect, but is not likely to adversely affect the southern DPS of green sturgeon (*Acipenser medirostris*), the southern DPS of Pacific eulachon (*Thaleichthys pacificus*), and the southern DPS of Pacific eulachon critical habitat. NMFS concurs with these determinations as described below.

6.1 Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon is listed as a threatened species, and includes all green sturgeon spawning populations south of the Eel River, with the only known spawning population being in the Sacramento River (71 FR 17757; April 7, 2006). Sub-adult and adult southern DPS of North American green sturgeon enter coastal bays and estuaries north of San Francisco Bay, CA, during the summer months to forage (Lindley et al. 2008). The southern DPS of North American green sturgeon's potential occurrence in the lower Klamath River is limited to only the sub-adult and adult life stages, only during the summer and fall, and only in the Klamath River estuary. Because the proposed action is not expected to adversely affect the physical, chemical, and biological resources in the Klamath River estuary, NMFS concurs with Reclamation that the proposed action may affect, but is not likely to adversely affect the southern DPS of North American green sturgeon.

6.2 Southern DPS of Pacific Eulachon

The southern DPS of Pacific eulachon is listed as threatened species in 2010 (75 FR 13012; March 18, 2010). Eulachon are semelparous and anadromous, spending most of their lives in marine environments before returning to freshwater to spawn once and die. After eulachon spawn, eggs attach to gravel or sand and incubate for 30 to 40 days, after which larvae drift to estuaries and coastal marine waters (Wydoski and Whitney 1979), and after three to five years, adults migrate back to natal basins to spawn.

In the Klamath River, adults rarely migrate more than 8 miles inland (NRC 2004). With funding from NMFS, the Yurok Tribal fisheries biologists surveyed for eulachon in the lower Klamath River and found only two eulachon in early 2011 and 40 in 2012 (Yurok Tribal Fisheries Program 2011, 2012). Yurok tribal fishermen also caught five eulachon in early 2011 (Yurok Tribal Fisheries Program 2011). Because the proposed action is not expected to adversely affect the physical, chemical, and biological resources in the Klamath River estuary, NMFS concurs with Reclamation that the proposed action may affect, but is not likely to adversely affect the southern DPS of Pacific eulachon.

6.3 Southern DPS Eulachon Critical habitat

In October 2011, NMFS designated final critical habitat for the southern DPS of Pacific eulachon (76 FR 65324; October 20, 2011). NMFS designated approximately 539 miles of riverine and estuarine habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS of eulachon. The designation includes 16 rivers and creeks extending from and including the Mad River, California to the Elwha River, Washington. In the Klamath River, critical habitat is designated from the mouth of the Klamath River upstream to the confluence with Omogar Creek at approximately river mile (RM) 10.5 from the mouth; however, critical habitat does not include any tribal lands of the Yurok Tribe or the Resighini Rancheria. Because the proposed action is not expected to adversely affect the physical, chemical, and biological resources in the Klamath River estuary, NMFS concurs with Reclamation that the proposed action may affect, but is not likely to adversely affect critical habitat designated for the southern DPS of Pacific eulachon.

7 STATUS AND ENVIRONMENTAL BASELINE OF THE LOST RIVER SUCKER AND THE SHORTNOSE SUCKER

In this section, we assess the range-wide condition of the SNS and the LRS (i.e., its status). We describe factors, such as life history, distribution, population sizes and trends, and evidence of resiliency and redundancy, which help determine the likelihood of both survival and recovery. In doing so, we describe how vulnerable each affected species is to extinction. This information will inform a population viability baseline against which the effects of the proposed action will be measured. We also present the Environmental Baseline of the affected species in this section; we focus on those environmental factors that have led to the species' current status. It is important to note that the action area encompasses the entire range of the LRS and the SNS and their critical habitat (discussed in Section 9 below).

Endangered Species Act regulations define the environmental baseline as "…the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02). The environmental baseline is an analysis of the factors that have, are, or will continue to affect listed species in the action area, not merely a recitation of the actions that have occurred or are occurring in the action area. The environmental baseline analysis will help us assess the effects the proposed action will have on listed species.

In Section 7 consultations on continuing actions, such as Reclamation's Klamath Project operations, separating baseline effects from the anticipated effects of the proposed action can be difficult. This is because operations of existing structures, such as dams and associated infrastructure, are integrally related to the existence of the structures themselves, but effects of the presence of the structures are not effects of the proposed action, and therefore are part of the environmental baseline. For example, on the east side of the action area, Clear Lake and Gerber Reservoir Dams block upstream sucker passage because they lack fish ladders. However, because that effect would occur even if there was no proposed action, blocked fish passage is not an effect of the action and instead is part of the environmental baseline.

For the Klamath Project, the non-operational effects of the infrastructure now in place, such as the blocked passage mentioned above, are part of the environmental baseline, but the effects of operating those structures to store, deliver, and drain water are effects of the proposed action.

7.1 Regulatory History

The LRS and the SNS were federally listed as endangered throughout their entire ranges on July 18, 1988 (53 FR 27130). They are also listed as endangered by the States of California (1974) and Oregon (1991). In 2007, the status of each of these species was reviewed by the USFWS (USFWS 2007a, b). A new 5-year status review of the LRS and the SNS has been initiated by the USFWS, and this review will be completed in 2013. A draft revision of the 1993 recovery plan for these species was published by the USFWS in 2011, and a final revised plan published in 2013 (USFWS 2013). The USFWS proposed critical habitat for the LRS and the SNS on December 1, 1994 (59 FR 61744), but the proposal was not finalized. On December 7, 2011, a revised proposal was published that included critical habitat in Klamath and Lake Counties, Oregon, and Modoc County, California (76 FR 76337). The final designation of critical habitat for the LRS and the SNS was published on December 11, 2012 (77 FR 73740).

7.2 Reasons for Listing

Although not explicitly stated in the final listing rule, the LRS and the SNS were listed because of the loss of populations of both species, a decline in numbers within both species' populations, and loss of habitat all of which resulted in a critical lack of resiliency and redundancy for each species (USFWS 2013). In this context, resiliency is the ability of a population or species to rebound after stressful environmental conditions, such as adverse water quality, increased predation, disease, drought, or climate change. Redundancy, in this context, involves multiple populations spread over the landscape to reduce the likelihood of simultaneous extirpation from catastrophic events, such as adverse water quality, drought, or disease.

Of the few populations of the LRS and the SNS that remain, most are very restricted in distribution and many lacks the ability to successfully reproduce. This condition was caused by several factors, including habitat loss, construction of barriers, overharvesting of adults, and entrainment of young individuals.

Suitable habitat for the LRS and the SNS was drastically reduced in extent and functionality due to the historical conversion of wetlands to agricultural use and construction of irrigation and hydroelectric facilities, which drained lakes and wetlands, created barriers to spawning habitat, and caused mortality by entraining fish. Chiloquin Dam on the Sprague River was cited as the most influential barrier at the time of listing because it blocked access to approximately 95 percent of potential river spawning habitat for UKL populations of the LRS and the SNS (53 FR 274130); the dam was removed in 2008. Nevertheless, many other significant physical barriers persist throughout the range of these species, limiting the ability of populations to reproduce or disperse, such as the Tule Lake populations (NRC 2004).

Overharvesting of adult LRSs and SNSs potentially contributed to declining population levels in UKL, especially for the LRS, but harvest has not been authorized since 1987 (USFWS 2007a, b). Entrainment of larval and juvenile suckers into irrigation and hydroelectric structures was also cited as a threat at listing, and this loss of young fish continues to threaten these species even though several major improvements to key structures (e.g., the A Canal fish screen) have been implemented.

Nonnative fishes were identified as a potential threat to the LRS and the SNS at the time of their listing because of potential competition and predation.

Lastly, mass mortality events in UKL are not new, but it is believed that as *Aphanizomenon flos-aquae* (AFA), a nitrogen-fixing blue-green alga or “cyanobacterium,” has increasingly dominated the system, the frequency of extreme fish die-off events has also increased (NRC 2004). Although conditions are most severe in UKL and Keno Reservoir, listed suckers throughout the Klamath Basin are vulnerable to water quality-related mortality (USFWS 2007a, b).

7.3 New Threats Identified Since Listing

7.3.1 Climate Change

Since the 1950s, western North America has experienced changes in the timing and amount of precipitation, including decreased snowfall, earlier snowmelt, and earlier peak spring runoff, which appear inconsistent with historically normal fluctuations, suggesting effects from anthropogenic sources (Hamlet et al. 2005, Stewart et al. 2005, Knowles et al. 2006). Climate models indicate that these trends are likely to continue (Barnett et al. 2008). In the upper Klamath Basin, 8 of the 10 lowest total annual inflows into UKL in the past 50 years occurred between 1991 and 2009, and, over the past decade, inflows to the lake have been about 9 percent less than over the previous 31 years. Additionally, the July through September inflows to UKL have declined by over 50 percent during the past 50 years (Mayer 2008, Mayer and Naman 2011).

The LRS and the SNS evolved in a region with highly variable precipitation, often with extended and severe droughts (Negrini 2002); however, given the current lack of recruitment into the adult population of each species, the absence of population connectivity (even in wet years), poor habitat conditions, and diminished abundance, LRS and SNS populations are highly vulnerable to negative impacts from climate change, especially increased drought. Threats from climate change not only include reduction in amounts of spring runoff and its timing, but are likely to also result in increasingly reduced water quantity, the spread of disease and parasites, and proliferation of invasive and nonnative species that could prey on or compete with suckers.

7.3.2 Disease, Predation, and Parasitism

Emerging information suggests that other natural factors may also be adversely affecting the suckers more than previously thought. For example, fish-eating birds, such as the American white pelican (*Pelecanus erythrorhynchus*), could have substantial negative impacts on adult sucker populations, especially those in Clear Lake where they could be exposed to pelican predation during the spawning migration in Willow Creek. Early data indicate that American white pelican predation rates on sub-adult or adult suckers in Clear Lake Reservoir may be as high as 20 percent in some years; however, additional research is needed to clarify the magnitude of this threat (Roby and Collis 2011; D. Hewitt, USGS, pers. comm. 2012). Additional, recently identified threats include algal toxins, which may have affected nearly 50 percent of 47 juvenile

LRSs assayed from UKL (Vanderkooi et al. 2010); and parasites, including *Neascus* spp., a trematode flatworm (Simon et al. 2012, Markle et al. 2013), anchor worm (*Lernaea cyprinacea*), a parasitic copepod (Simon et al. 2012), *Trichodina* sp., an external ciliate protozoan; and the bacterium *Flavobacterium columnare*, which causes gill rot (Holt 1997, Foott 2004, Foott et al. 2010). Markle et al. (2013) recently estimated an additional 3.7 percent daily mortality for juvenile SNSs that were infected with *Neascus* spp. (black spot disease) compared to uninfected individuals. There is new information concerning the bacterial flora on the skin of juvenile suckers (Burdick et al. 2009b), but it is unknown if this negatively affects the fish.

The LRS and the SNS are known to have at least two groups of multicellular, invertebrate parasites: *Neascus* and *Lernaea. Neascus,* or "black-spot disease," is a catch-all term for a group of trematode flatworms that cause similar infections in fish (Kirse 2010). The larval trematodes (a parasitic flat worm)burrow under the skin of the fish, resulting in a black cyst. The *Neascus* life cycle progresses through snails, then fish, and finally a fish-eating bird, all of which are seasonally numerous at UKL. Parasitic infections can cause physiological stress, blood loss, decreased growth rates, reduced swimming performance, lower overwinter fitness, and mortality, especially in small fish (Marcogliese 2004, Kirse 2010, Ferguson et al. 2011). In some instances, parasites can also make hosts more vulnerable to predators by affecting their morphology and/or behavior (Marcogliese 2004). Limited evidence is beginning to emerge concerning the effects of these parasites on listed Klamath suckers and it shows that parasites are likely an important source of mortality for age-0 SNS (Markle et al. 2013).

7.4 LRS and SNS Life History

The LRS and the SNS are adapted to lake environments. The LRS is the only extant member of the genus *Deltistes* (Miller and Smith 1967), and the SNS is one of three recognized species in the genus *Chasmistes* (Moyle 2002). Both species are relatively large, with a maximum size between 24 to 31 in (61 and 80 cm). The LRS and the SNS feed on zooplankton and small benthic invertebrates taken from or near soft substrates (Scoppettone and Vinyard 1991).

Both species spawn from February through May over rocky substrates in habitats less than 4 ft (1.2 m) deep in rivers and at shoreline springs (Buettner and Scoppettone 1990). In UKL, it appears that more than 95 percent of adults spawn every year (Hewitt et al. 2012). Females are highly fecund, producing from 44,000 to over 200,000 eggs per LRS female and 18,000 to 72,000 per SNS female per year, of which only a very small percentage survive to become juveniles (NRC 2004). Females typically broadcast their eggs in the company of two males (Buettner and Scoppettone 1990), and the fertilized eggs settle within the top few inches of the substrate until hatching 1 week later.

Approximately 10 days after hatching, larvae emerge out of the substrate (Buettner and Scoppettone 1990). Most larvae spawned in streams quickly drift downstream into lake habitat. Larval movement away from the spawning grounds begins in April and is typically completed by July (Klamath Tribes 1996, Tyler et al. 2004, Ellsworth et al. 2010). Once in lake habitats, SNS larvae predominantly use nearshore areas adjacent to and within emergent vegetation (Klamath Tribes 1996, Cooperman and Markle 2004, Crandall et al. 2008), but LRS larvae tend to occur more often in open water habitat (Burdick and Brown 2010) than near vegetated areas.

Sucker larvae transform into age-0 juveniles at about 1 inch (less than 3 cm) total length by mid-July. Age-0, which are individuals younger than 1 year, juvenile SNS primarily use relatively shallow (<4 ft) vegetated areas, but may also begin to move into deeper, unvegetated offshore habitats before the end of their first year (Terwilliger et al. 2004, Hendrixson et al. 2007a, Hendrixson et al. 2007b, Bottcher and Burdick 2010, Burdick and Brown 2010). Age-0 LRS juveniles also tend to be less associated with shallow vegetated habitat than SNS juveniles. Little is known about the ecology of older juvenile suckers (ages 1–4). SNSs and LRSs juveniles begin recruiting into the adult population at 4 to 7 years of age, with LRSs taking longer than SNSs and females of both species taking longer than males to reach sexual maturity (Buettner and Scoppettone 1990, Perkins et al. 2000a).

Adult LRSs and SNSs inhabit lake environments with water depths of 3 to 15 ft (1 to 5 m), but appear to prefer depths from 5 to 11 ft (1.5 to 3 m; Peck 2000, Reiser et al. 2001), with LRSs typically inhabiting slightly deeper habitats than SNS (Banish et al. 2009). Adult LRSs and SNSs in UKL primarily occur in the northern half of UKL during the summer (Peck 2000, Banish et al. 2009), but become concentrated near and within Pelican Bay when water quality is adverse in the remainder of the lake (Perkins et al. 2000b, Banish et al. 2009). In the spring, congregations also form near tributaries or shoreline areas prior to spawning (Janney et al. 2008).

The LRS and the SNS exhibit many adaptations characteristic of long-lived species. Juveniles grow rapidly until reaching sexual maturity. Under favorable conditions, adults can have high survival rates, which enable populations to outlive adverse periods, such as droughts. Once achieving sexual maturity, LRSs live an average of 12.5 years under current conditions in UKL (D. Hewitt, USGS, pers. comm. 2010). Similarly, SNS adults are estimated to live an average of 7.4 years after joining the adult population. Thus, for those individuals that survive to adulthood, we expect an average total life span of 20 years for the LRS and 12 years for the SNS, based on the average time to maturity and average adult life spans, with maximum ages of up to 57 and 33 years, respectively (Scoppettone 1988, Buettner and Scoppettone 1990, Terwilliger et al. 2010).

7.4.1 LRS and SNS Distribution

The LRS and the SNS are endemic to the upper Klamath River Basin, including the Lost River and Lower Klamath sub-basins (Moyle 2002). Populations of both species currently exist in UKL, its tributaries, and downstream in the Klamath River reservoirs; although SNS dominates in Keno Reservoir and the hydropower reservoirs in the Klamath River (Desjardins and Markle 2000, Kyger and Wilkens 2012a). Both species also occur in Tule Lake, Clear Lake, and the Lost River. Only the SNS occurs in Gerber Reservoir, but, based on genetic evidence, this population appear to be intercrosses between the SNS and the Klamath largescale sucker (*Catostomus snyderi*, KLS; Tranah and May 2006).

Prior to listing, populations of the LRS were extirpated from Lower Klamath (including Sheepy Lake; Coots 1965), and a population of the SNS was extirpated from Lake of the Woods (Andreasen 1975). Subpopulations of the LRS or the SNS that were spawning at Barkley, Harriman, other springs, and smaller tributaries to UKL have also been extirpated (USFWS 2013). Other than populations in UKL, Clear Lake, and Gerber Reservoir, all other populations of both species are believed to be population sinks, populations that result from dispersal from a producing population, but cannot maintain themselves through larval production. Suckers are suspected by some to spawn in the Link River (Smith and Tinniswood 2007), the Lost River below Anderson-Rose Dam (Hodge and Buettner 2009), in the upper reach of Copco Reservoir (Beak Consultants Inc. 1988), and above Malone Dam (Sutton and Morris 2005); however, due to small numbers, the lack of suitable habitat, and presence of predators, it is unlikely these attempts lead to substantial larval production.

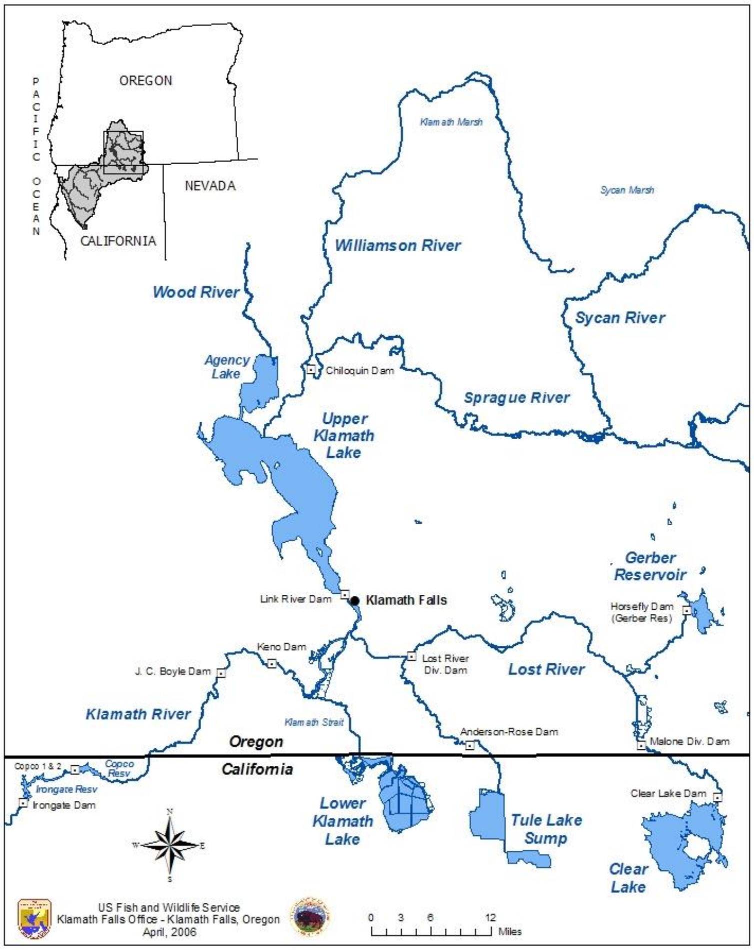


Figure 7.1. The LRS and the SNS currently occur in UKL, reservoirs along the Klamath River, Clear Lake, Tule Lake, and the Lost River; the SNS is also found in Gerber Reservoir.

7.4.2 LRS and SNS Recovery Units

The 2013 revised recovery plan for the LRS and the SNS identifies recovery units for both of these species, based on the limited information on genetic and ecological distinction between sub-basins (USFWS 2013). The UKL Recovery Unit is subdivided into four management units: (1) UKL river-spawning individuals; (2) UKL spring-spawning individuals (LRS only); (3) the Keno Reservoir Unit, including the area from Link River Dam to Keno Dam; and (4) the reservoirs along the Klamath River downstream of Keno Dam, known as the Klamath River Management Unit. The Lost River Recovery Unit is also subdivided into four management units: (1) Clear Lake; (2) Tule Lake; (3) Gerber Reservoir (SNS only), and (4) the Lost River proper (mostly SNS). By specifying recovery units, USFWS indicates that recovery cannot occur without viable populations in each recovery unit; however, this does not mean that each management unit has equivalent conservation value or is even necessary for species recovery to be achieved. Viable populations are ones that are able to complete their life cycle regularly with recruitment and diverse age composition of the adult population.

In the 2013 recovery plan for the LRS and the SNS (USFWS 2013), the criteria to assess whether each species has been recovered are focused on reduction or elimination of threats, and demographic evidence that sucker populations are healthy. The threats-based criteria for down-listing include: (1) restoring and enhancing habitats, including water quality; (2) reducing adverse effects from nonnative species; and (3) reducing losses from entrainment. To meet the population-based criteria for delisting each species must exhibit an increase in spawning population abundances over a sufficiently long period to indicate resilience, as well as establish spawning subpopulations within UKL.

7.4.3 LRS and SNS Genetics

In an assessment of mitochondrial DNA (mtDNA), Dowling (2005) reported that the LRS is relatively distinct genetically from the other sucker species in the Klamath Basin. Similarly, microsatellite markers indicate that LRSs do not regularly interbreed with the other catostomids in the Klamath Basin (Tranah and May 2006). In addition, differences in mtDNA of LRS populations in the upper Klamath Basin compared to those in the Lost River sub-basin suggest that these should be treated as separate LRS units (Dowling 2005) for purposes of maintaining genetic diversity.

Conversely, little distinction between SNS and KLS mtDNA and microsatellite markers has been found (Dowling 2005, Tranah and May 2006), suggesting that interbreeding has occurred in the past and likely continues to occur between these species. This is especially true in the Lost River sub-basin; although morphological, behavioral, and ecological distinctions are maintained in most populations (Markle et al. 2005). Increased hybridization resulting from human intervention can be cause for concern for imperiled species, and may even lead to extinction (Rhymer and Simberloff 1996). However, data suggest that intercrossing among Klamath Basin suckers is consistent with a pattern of historical intercrossing, which is not uncommon for the sucker family *Catostomidae* (Dowling and Secor 1997, Dowling 2005, Tranah and May 2006). Further studies are needed to determine the extent, causes, and effects of this intercrossing, but based on the historical pattern of intercrossing of these species and the fact that many individuals retain much of the SNS phenotype we consider these SNSs to be protected under the ESA. A genetic distinction among SNS populations between basins is weakly defined. Currently, there is no opportunity for gene flow between the populations of both species because of many significant physical barriers.

7.4.4 LRS and SNS Range-wide Population Trends

Starting in the late 1800’s, large areas of sucker habitat were converted to agriculture and barriers were created that isolated populations from spawning grounds. Although there are no survey records until the 1900's, it is likely that these once superabundant species began to decline in numbers around the turn of the 20th century concurrent with significant destruction and degradation of sucker habitat. Later, from the 1960s to the early 1980s, recreational harvests of suckers in UKL progressively decreased (Markle and Cooperman 2002), which reflected further declines in the LRS and SNS populations and led to their listing under the ESA in 1988. From 1995 to 1997, water quality-related die-offs killed thousands of adult suckers in UKL (Perkins et al. 2000b). Over that three-year period, more than 7,000 dead suckers were collected and many other dead suckers were likely present but not detected.

More recently (between 2002 and 2010), the abundance of LRS males in the lakeshore-spawning subpopulation in UKL decreased by 50 to 60 percent, and the abundance of females in UKL decreased by 29 to 44 percent (Hewitt et al. 2012; Figure 7.2). It is not clear if the river-spawning subpopulation of the LRS in UKL has increased or decreased between 2002 and 2010 because of improvements in sampling methodology part way through the study that give the appearance of a large influx of individuals, but it is likely that this population decreased proportionately similar to the spring-spawning population (Hewitt et al. 2012).

Capture-recapture data indicate that the UKL SNS adult population decreased in abundance by 64 to 82 percent for males and 62 to 76 percent for females between 2001 and 2010 (Hewitt et al. 2012). Although the adult populations of both species in UKL have declined substantially, the SNS adult population is at a greater risk of extirpation from UKL than LRS because it had declined to a greater degree and there are approximately 10 times LRS in UKL than SNS (Hewitt et al. 2012). If the trend from 2001 through 2010 continues for the SNS in UKL we may expect that roughly 1,000 will remain by the end of the term of the BiOp in this water body. However, the risk of extirpation becomes even more likely given that the relatively advanced age of most individuals in UKL will likely result in an acceleration of declining trends during the BiOp term as individuals begin to succumb to old age.

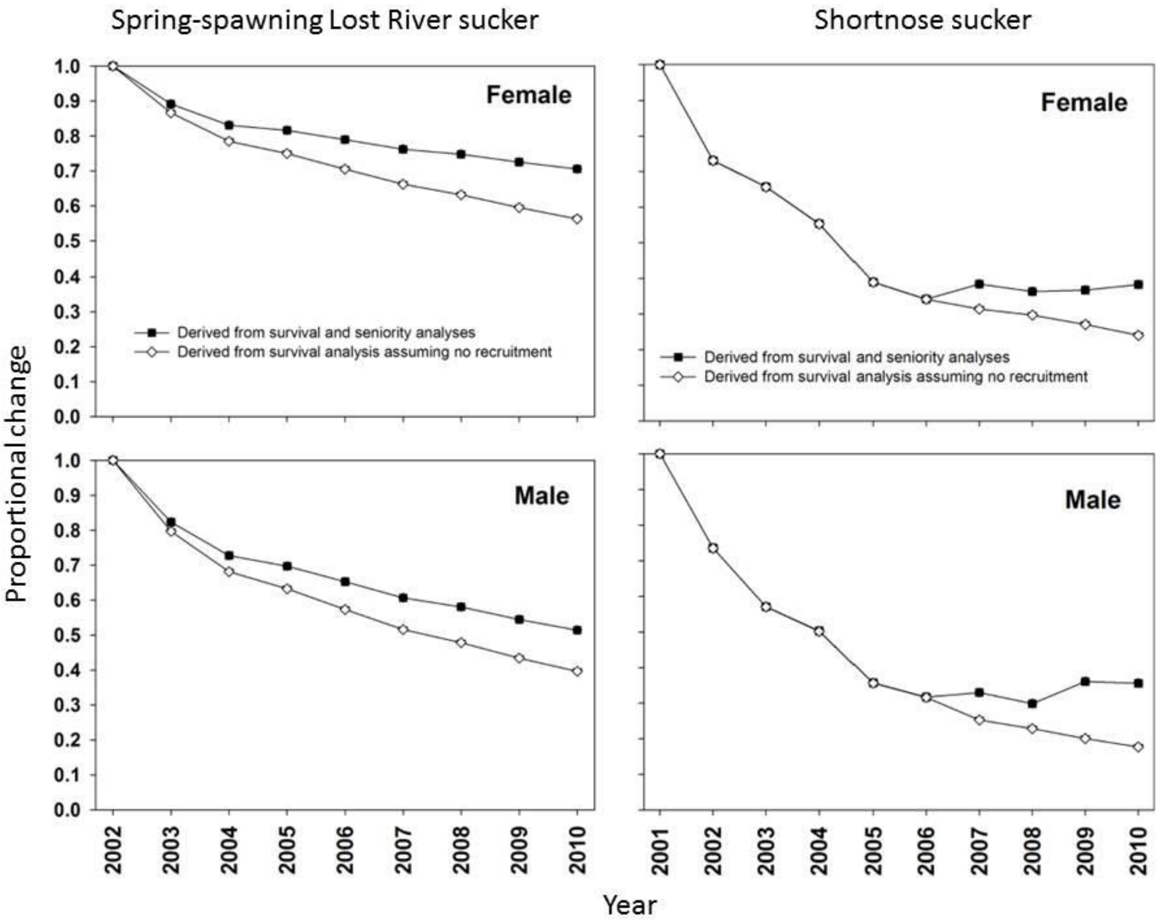


Figure 7.2. Adult spawning populations of suckers in UKL have consistently declined since at least 2001, as estimated by two approaches using mark-recapture models in Program MARK (from Hewitt et al. 2012). The number of spawning female LRS in UKL has declined by 60 to 80 percent between 2002 and 2010.

Recent LRS and SNS size distribution trends reveal that the adult spawning populations within UKL are comprised mostly of similar age, relatively old individuals. Since the late 1990s, median lengths of populations of SNS have increased by approximately 0.16 in (4 millimeters [mm]) per year and 0.35 to 0.47 in (9 to 12 mm) per year for the LRS (Hewitt et al. 2012). If younger individuals (which are typically smaller) were frequently joining the population the median length would remain stable, suggesting that recruitment of new adults is minimal to nonexistent. Most adult suckers currently in UKL are believed to be the result of spawning that occurred in the early 1990s (Janney et al. 2008). These fish are now approximately 20 years of age, and are well beyond the average life span of 12 years for the SNS and equal to that of 20 years for the LRS. Even though viable eggs and larvae are produced each year, a bottleneck during subsequent life stages causes a lack of recruitment of new adults into UKL sucker populations, which continue to exist only because of their long life. However, this trend is especially untenable for the SNS, and, without substantial recruitment in the next decade, the population will be so small that it is unlikely to persist.

Insufficient monitoring data are available to determine trends for other LRS and SNS populations, but since the declining populations in UKL are the source of most of the LRS and SNS populations elsewhere, we expect the trends in those populations to be similar to those in UKL. Loss of the UKL LRS and SNS populations would put both species at a high risk of extinction because the UKL populations represent approximately 40 to 80 percent of the total rangewide population of the SNS and the LRS, respectively (Table 7.1), and would reduce the number of self-sustaining populations from two to one for the LRS, and from three to two for the SNS. If these losses occurred it would significantly reduce both the resiliency and the redundancy of the LRS and SNS populations range-wide. Resiliency and redundancy are very important factors for survival and recovery of these species (USFWS 2013).

7.4.5 LRS and SNS Population Dynamics

7.4.5.1 Adult Population Sizes

Because of the wide-ranging behavior, expansive habitat, and rarity of these species, obtaining accurate population estimates is impracticable. However, long-term monitoring using capture-recapture methods provide accurate information on relative changes in abundance (Hewitt et al. 2010, 2012). For example, in 2011, UKL monitoring detected or captured approximately 22,000 tagged LRS (Hewitt et al. 2012). Approximately 37 percent of these individuals were spawning at the springs along the eastern shoreline of the lake. The proportion of tagged individuals in the total UKL population is unknown. If that were known, it would allow for the calculation of a relatively accurate estimate of overall numbers in UKL. However, the proportions of tagged to untagged individuals in direct captures suggest that the LRS population in UKL likely numbers between 50,000 and 100,000 adults (Hewitt et al. 2012). The number of adult SNSs in UKL is likely to be fewer than 25,000, given that only approximately 10,000 individual SNSs were detected or captured during the 2011 spawning season (Hewitt et al. 2012).

In Clear Lake, SNSs are more abundant than LRSs. Approximately 2,500 tagged SNSs were detected during the spawning run up Willow Creek in 2011 (B. Hayes, USGS, pers. comm. 2011); slightly less than 500 tagged LRSs were detected during the same period at this location. Although reliable estimates of total population numbers are unavailable, but data suggest that fewer than 25,000 adult SNSs and fewer than 10,000 adult LRSs occur in Clear Lake.

Data on LRS and SNS populations in Keno Reservoir, Klamath River reservoirs, Tule Lake, Gerber Reservoir, and the Lost River are limited, but the monitoring efforts completed for these populations indicate low numbers of each species, with perhaps fewer than 5,000 individuals total for the LRS and the SNS in Tule Lake (Hodge and Buettner 2009), Keno Reservoir (Kyger and Wilkens 2010a), and the Klamath River reservoirs below Keno (Desjardins and Markle 2000). In 2010, 413 suckers (187 LRS + 227 SNS and 3 unknowns were captured and relocated to UKL (Courter et al. 2010). SNS dominate in the Keno Reservoir and downstream in the hydropower reservoirs (Desjardins and Markle 2000, Kyger and Wilkens 2012b). Gerber Reservoir may be an exception to this because spawning surveys in 2006 detected approximately 1,700 of the nearly 2,400 SNSs that had been tagged the previous year (Barry et al. 2007c). The approximate size of known SNS and LRS populations are shown in Table 7.1 below. Based on limited data, we estimate that the approximate total range-wide adult population of the LRS is 65,000 to 115,000 individuals, and less than 60,000 individuals for the SNS.

Table 7.1. Estimated LRS and SNS adult sucker population sizes. Note: The estimate for UKL is based on Hewitt et al. (2012). Clear Lake and Gerber Reservoir contain self-sustaining sucker populations. The "Other Areas" include Keno Reservoir, Tule Lake, Lost River, and four Klamath River reservoirs downstream of Keno that are considered sink populations.

Location	No. of Adult LRS	No. of Adult SNS
UKL	50,000-100,000	<25,000
Clear Lake	<10,000	<25,000
Gerber Reservoir	None	<5,000
Other Areas	<5,000	<5,000

7.4.5.2 LRS and SNS Population Demographics

Vital rates (e.g., survival and recruitment) of SNS and LRS adults in UKL have varied little over the past decade. Annual adult survival rates of the SNS in UKL appear to vary more than the LRS, but adults of both species in UKL appear to be relatively stable (Hewitt et al. 2012), excluding years of large fish die-offs as in 1995, 1996, and 1997. Modeling of LRS and SNS adult populations since 2001 suggests a low rate of recruitment (Hewitt et al. 2012), which has resulted in adult populations for both species that are homogenous in size and age. If this lack of recruitment continues, it will cause instability and eventually lead to extirpation of these species from UKL. It is generally accepted that the last substantial recruitment for both the LRS and the SNS in UKL occurred in the late 1990s, from fish that were spawned earlier in the decade (e.g., 1991). Although it is difficult to verify this finding using standard fish-ageing techniques (given the long life of these species, annual growth rings are often difficult to differentiate), the size distribution of spawning adults appears to corroborate this view. Between 2000 and 2011, the length distribution of both species in UKL steadily shifted upwards, with few smaller (and presumably younger) individuals being present (Hewitt et al. 2012).

Given the scarcity of juvenile suckers in UKL and based on the time it takes for these species to become sexually mature, it likely will be at least 4 years before substantial recruitment into the adult age class occurs because there are no known cohorts in the queue. Although we do not know specifically how this current uniform age distribution compares to historical conditions, healthy adult populations of long-lived species should generally possess multiple reproducing year-classes.

In Clear Lake, SNS vital rates appear to be fairly consistent, given the normal distribution of size classes of captured individuals since 2004 (Hewitt and Janney 2011; based on the assumption that size is generally related to age). During the same period, annual size distribution surveys indicated a group of sub-adult LRS was progressing towards sexual maturity, but this cohort inexplicably disappeared from samples taken in 2008 (E. Janney, USGS, pers. comm. 2011).

7.5 Summary of Status of the LRS and the SNS

The status of the LRS and the SNS has declined since listing. The SNS is especially vulnerable because of substantial population declines in UKL and relatively small populations overall. Adverse water quality in UKL in the 1990s caused massive die-offs of both the LRS and the SNS. Since 2001, SNSs in UKL have declined by as much as 70 to 80 percent and LRSs by as much as 40 to 60 percent, suggesting a lack of resiliency. SNSs in UKL are also vulnerable because most are well past their average life expectancy, and LRSs are at their average life expectancy, thus the rate of decline could increase if there is not substantial recruitment into the adult age class. However, recruitment of both species into the adult population in UKL in the past decade has been nearly nonexistent, and there is no evidence of large cohorts of young suckers that could enter the adult population in the next few years. Loss of the UKL populations would leave only one self-sustaining population of the LRS and two populations of the SNS; thus, there is little redundancy for either species, adding to their risk of extinction. Given this information, the Service finds that LRS and SNS populations, especially the SNS population in UKL, are at a high risk of extinction.

7.6 Survival and Recovery Needs of the LRS and the SNS

The 2013 revised recovery plan for the LRS and SNS (USFWS 2013) describes their survival and recovery needs, which are:

- Adequate quality and quantity of habitat to support the needs of all life stages of LRS and SNS.
    - Improved water quality to a level where adverse effects are not sufficient to threaten the continued persistence of the LRS and the SNS.
    - Connectivity throughout the range of LRS and SNS to ensure appropriate genetic exchange among populations, to provide access to spawning and refugial areas, and to permit return of downstream migrants.

- A sufficient number of viable, self-sustaining populations of the LRS and SNS to buffer against localized extirpations.

    - Substantially reduced entrainment of larval, juvenile and adult LRS and SNS particularly in UKL.
    - Increased frequency and magnitude of recruitment into the adult spawning populations of both the LRS and the SNS.
    - Populations of sufficient sizes to ensure genetic variability to enable LRS and SNS to respond to changing ecosystem conditions.

7.7 Reclamation's Klamath Project

7.7.1 Hydrologic Alteration

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.) authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of water for the reclamation of arid and semiarid lands in the western States. Congress facilitated development of the Klamath Project by authorizing the Secretary to raise or lower the level of Lower Klamath and Tule Lakes and to dispose of the land uncovered by such operation for use under the Reclamation Act of 1902. The Oregon and California legislatures passed legislation for certain aspects of the Klamath Project, and the Secretary of the Interior authorized construction May 15, 1905, in accordance with the Reclamation Act of 1902 (Act of February 9, 1905, Ch. 567, 33 Stat. 714). The Project was authorized to drain and reclaim lakebed lands in Lower Klamath and Tule Lakes, to store water of the Klamath and Lost Rivers, including water in the Lower Klamath and Tule Lakes, to divert and deliver supplies for Project purposes, and to control flooding of the reclaimed lands.

Starting around 1912, construction and operation of the numerous facilities associated with Reclamation’s Klamath Project significantly altered the natural hydrographs of the upper and lower Klamath River. In 1922, the level of UKL was raised by the construction of the Link River Dam. Reclamation’s Klamath Project now consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 200,000 ac (81,000 ha) of irrigated farmlands in the Upper Klamath River basin (Reclamation 2012).

7.7.2 Project Water Consumption

Spring and summer deliveries of irrigation water to the Klamath Project from UKL are trending upward during the period of record. Historic and modeled April through November (spring/summer in terms of the proposed action model parameters) deliveries to the Project from UKL is shown in Figure 7.3 and Figure 7.4, respectively.

While the trends suggest increases in Project deliveries when considered in isolation, they may also be examined with respect to other water-related trends in the upper Klamath Basin. As described in section 7.3.1, *Climate Change*, average annual air temperature in the upper Klamath Basin has been increasing over several decades and snow-water equivalent has been declining. In addition, although the declining trend is not apparent in the past two decades, annual net inflow to UKL has declined over the full 31-year period of record (POR) and the trend is statistically significant (Section 7.10.2*, UKL and Tributaries Water Quantity and Trend Analysis*). Therefore, it is reasonable to consider that the increase in Project deliveries could be caused by changes in irrigation and cropping patterns, additional land under irrigation, decadal shifts in weather, global warming, conjunctive uses of surface water and groundwater, or a combination of factors. Many of these individual factors have not been examined rigorously in the Klamath Basin and the relationships between them are poorly understood or have not been examined at all. The trend of Project deliveries is one that must be evaluated more fully and tracked more closely during the future.

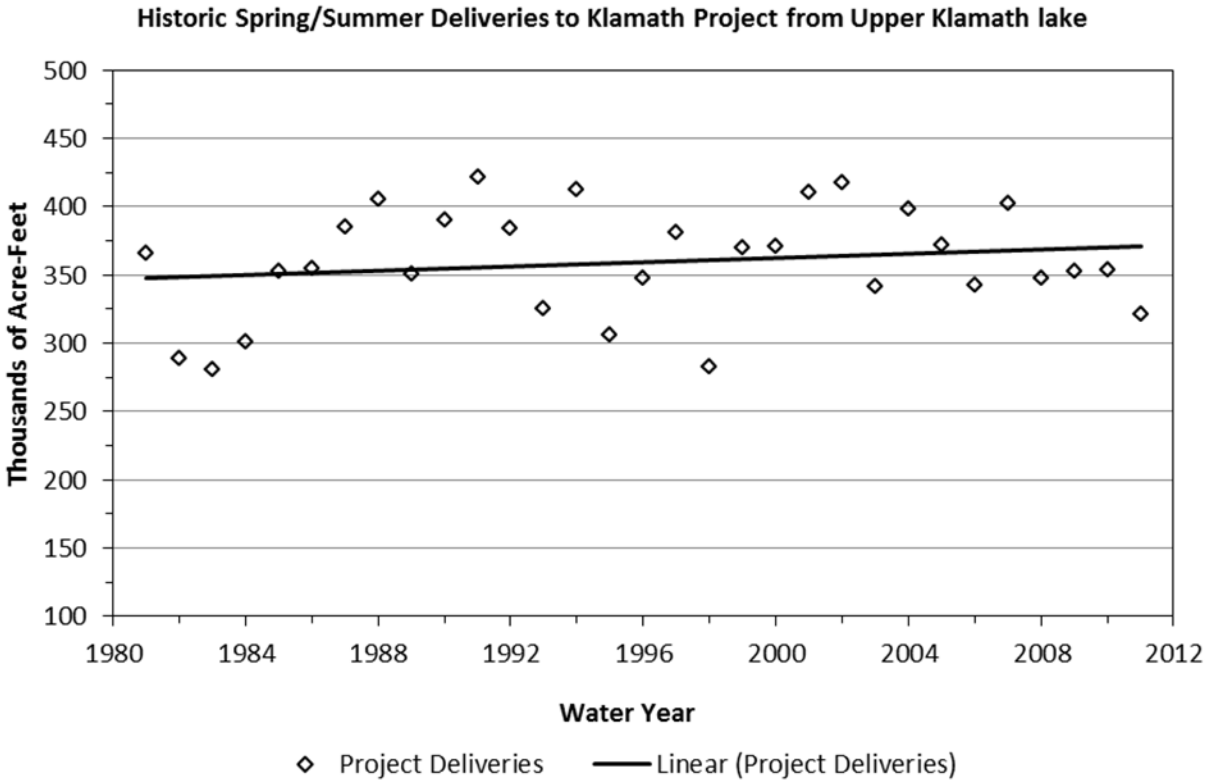


Figure 7.3 Historic April through November deliveries to Project from UKL.

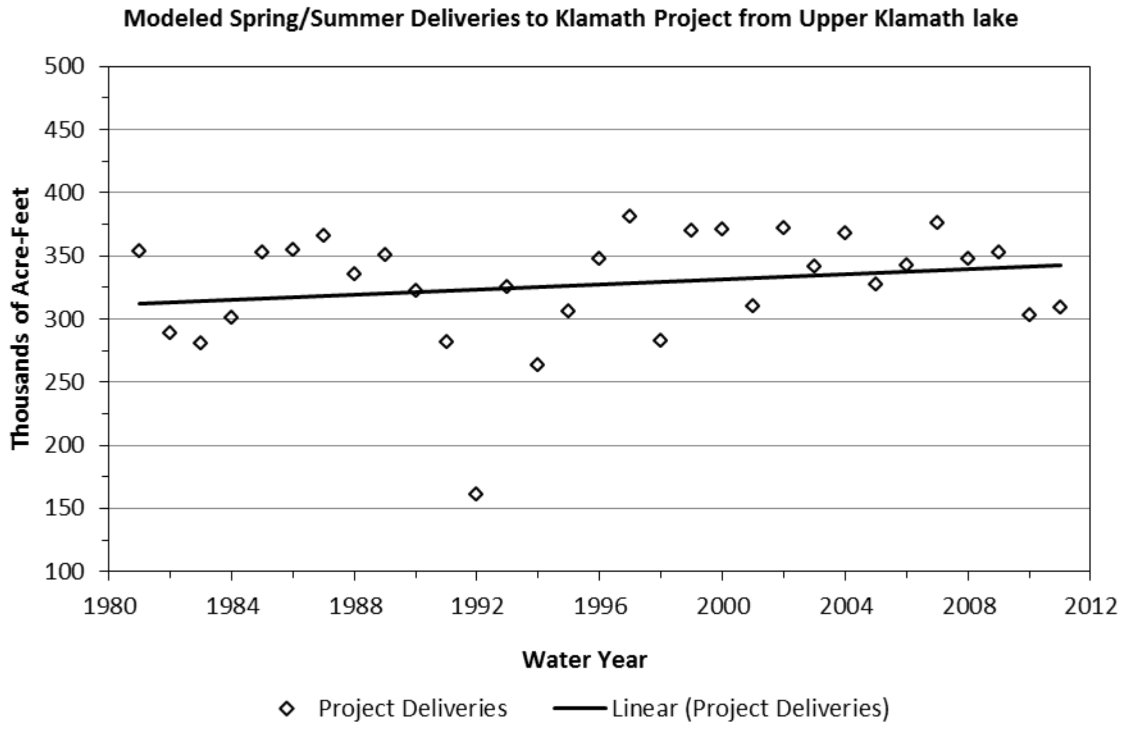


Figure 7.4 Modeled April through November deliveries to Project from UKL.

7.7.3 Effects of Historical Project Entrainment on the LRS and the SNS

The effects of entrainment on the LRS and the SNS caused by the Project have been described in BiOps on proposed Project operations, the most recent BiOp being in 2008 (USFWS 2008, pages 72–76 and 127–135); that discussion is herein incorporated by reference. Entrainment causes the largest quantified Project-caused loss of the LRS and the SNS, and is estimated to annually involve millions of larvae and tens of thousands of juveniles (Gutermuth et al. 2000a, b, USFWS 2008). Entrainment of planktonic sucker larvae in UKL is thought to be related to drift and wind-driven circulation patterns (USFWS 2008), but entrainment of juvenile suckers that are more bottom-oriented is likely more complex and probably affected by multiple factors. Juvenile suckers that are entrained at the A Canal and Link River Dam could be dispersing, showing an avoidance response to poor habitat conditions, weakened by inhospitable conditions, or a combination of these and other factors. Gutermuth et al. (2000a, b) found that entrainment of suckers at the Link River was higher during poor water quality events, and thus leaving the lake could be an avoidance response because fish tend to avoid unfavorable conditions such as low DO or high water temperatures (Sullivan et al. 2003).

Prior to construction of the Link River Dam, sucker dispersal downstream into Lower Klamath Lake was likely a natural part of the LRS's and the SNS's life cycle. However, now with the higher summer flows at the outlet of UKL to meet irrigation deliveries and downstream river-flow requirements, entrainment of age-0 juvenile suckers is likely greater than it was prior to lake management (USFWS 2008), and with loss of access to Lower Klamath Lake, rearing habitat for the LRS and the SNS has been drastically reduced and degraded.

7.8 PacifiCorp's Hydroelectric Project on the Klamath River from Keno Dam to Iron Gate Dam

Lake habitats that support sucker populations were created in the Klamath River as a result of construction of four dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) that comprise the PacifiCorp Klamath Hydroelectric Project. No lake habitat existed historically in the Klamath River below the Keno Reef, located upstream of the Keno Dam. LRS and SNS populations (mostly SNS) have expanded into these lake habitats, most likely from downstream drift of larvae and juveniles from UKL (Desjardins and Markle 2000). Populations in the Klamath River hydropower reservoirs are small compared to those in UKL, Gerber Reservoir, and Clear Lake (USFWS 2002, 2007c). Factors affecting sucker populations in the Klamath River reservoirs are discussed in detail in the FERC BiOp for the proposed relicensing of the Klamath Hydroelectric Project (USFWS 2007c). The greatest threats to suckers in these reservoirs likely come from adverse water quality and nonnative fishes.

7.9 Climate Change

7.9.1 Western United States

In the western United States, there is a strong link between climate and the availability of water resources. Surface water volume and recharge to groundwater are based primarily on winter precipitation and snowpack. Climate change effects caused by global warming began in the mid-20th Century and are continuing (Barnett et al. 2008, Christensen et al. 2004). The effects of climate change between 1950 and 2000 include water shortages and changes in the timing of runoff. The principal factors being (1) a shift to more winter precipitation falling as rain instead of snow in mountainous regions, (2) earlier snow melt as a result of warming winter temperatures, and (3) associated increases in river flow in the spring and decreases in the summer and fall (Barnett et al. 2008). Continuation of climate change is expected to significantly affect water resources in the western United States by the mid-21st century, and evidence suggests that the Klamath Basin region's climate is already changing (Hayes 2011). Climate change is generally predicted to result in increased air and water temperatures, decreased water quality, increased evapotranspiration rates, increased proportion of precipitation as rain instead of snow, earlier and shorter runoff seasons, and increased variability in precipitation patterns (Reclamation 2011). Several studies have shown declining snow-pack, earlier spring snowmelt, and earlier stream runoff in the western United States over the past few decades (Hamlet et al. 2005, Regonda et al. 2005, Stewart et al. 2005, Knowles et al. 2006). Winter precipitation and snow-pack are strongly correlated with streamflow in the Pacific Northwest (Leung and Wigmosta 2004).

Increasing temperature is the major driver of these observed trends, particularly at the moderate elevations and relatively warm winter temperatures characteristic of the Pacific Northwest (Hamlet et al. 2005, Stewart et al. 2005). Temperatures are projected to continue increasing by approximately 0.36˚ F (0.2 ˚C) per decade globally for the next several decades (Meehl et al. 2007).

7.9.2 Klamath Basin

The Oregon Climate Division 5 (includes the high plateau area of the upper Klamath Basin) temperature dataset and the U.S. Historical Climatology Network temperature dataset for Crater Lake show warming trends in winter temperatures since the 1970s (Mayer 2008). Recent winter temperatures are as warm as or warmer than at any time during the last 80 to 100 years (Mayer 2008). Air temperatures over the region have increased by about 1.8º to 3.6º F (1° to 2º C) over the past 50 years and water temperatures in the Klamath River and some tributaries have also been increasing (Bartholow 2005, Flint and Flint 2012). Reclamation (2011) reports that the mean annual temperature in Jackson and Klamath Counties, Oregon, and Siskiyou County, California, increased by slightly less than 1.8º F (1° C) between 1970 and 2010. During the same period, total precipitation for the same counties decreased by approximately 2 inches (5.08 cm) (Reclamation 2011).

In conjunction with rising temperatures, snow water equivalent has been declining. Regonda and others (2005) analyzed western states data from 1950 through 1999, including data from the Cascade Mountains of southern Oregon. Their findings show a decline in snow-water equivalent of greater than 6 inches (15.24 cm), an approximate 20 percent reduction in snow water equivalent, during March, April, and May in the southern Oregon Cascades for the 50-year period evaluated.

Analysis of climatologic and hydrologic information for the upper Klamath Basin indicates UKL inflows, particularly base-flows, have declined over the last several decades (Mayer and Naman 2011). Recent analyses completed for this BiOp confirm the trend in declining inflow to UKL from 1981 through 2012, and also demonstrate declining flows in the Sprague and Williamson Rivers (major tributaries to UKL) during the POR. However, trends change markedly depending on the selected period of record and trends for different time frames (e.g. 1991 through 2012 and 2001 through 2012) demonstrate increasing net inflow to UKL. Inflow to UKL and flow in the Sprague and Williamson Rivers are strongly dependent on climate, particularly precipitation, as demonstrated in Mayer and Naman (2011). Part of the decline in flow is explained by changing patterns in precipitation; however, other factors are very likely involved as well, including increasing temperature, decreasing snow-water equivalent, increasing evapotranspiration, and increasing surface water diversions or groundwater pumping upstream of UKL (Mayer 2008; Mayer and Naman 2011).

Projections of the effects of climate change in the Klamath Basin suggest temperature will increase in comparison to a 1961 through 2000 comparison period (Barr et al. 2010; U.S. Bureau of Reclamation 2011). Projections are based on ensemble forecasts from several global climate models and carbon emissions scenarios. Although none of the projections include data for the specific period of the proposed action, anticipated temperature increases during the 2020s compared to the 1990s range from 0.9 to 1.4° F (0.5 to 0.8° C) (Reclamation 2011). During the 2035 and 2045 period, temperature increases are expected to range from 2.0 to 3.6° F (1.1 to 2.0° C), with greater increases in the summer months and lesser increases in winter (Barr et al. 2010).

Effects of climate change on precipitation are substantially more difficult to estimate and models used for the Klamath Basin suggest decreases and increases. During the 2020s, Reclamation

(2011) projects an annual increase in precipitation of approximately 3 percent compared to the 1990s. Reclamation (2011) also suggests that an increase in evapotranspiration will likely offset the increase in precipitation. In the 2035 and 2045 period, the change in annual precipitation compared to the 1961 through 1990 is expected to range from approximately -9 percent to +3 percent (Barr et al. 2010). Within the boundaries of the annual change in precipitation, December through February precipitation is expected to increase by up to 10 percent while June through August precipitation is expected to decrease between 15 and 23 percent (Barr et al. 2010).

Reclamation (2011) projects that snow-water equivalent during the 2020s will decrease throughout most of the Klamath Basin, often dramatically, from values in the 1990s. Projections suggest that snow-water equivalent will decrease 20 to 50 percent in the high plateau areas of the upper basin, including the Williamson River drainage. Snow-water equivalent is expected to decrease by 50 to 100 percent in the Sprague River basin and in the vicinity of Klamath Falls. In the lower Klamath Basin, Reclamation projects decreases in snow water equivalent between 20 and 100 percent. The exception to the declines is the southern Oregon Cascade Mountains, where snow water equivalent is projected to be stable or increase up to 10 percent (U.S. Bureau of Reclamation 2011).

Reclamation also projects annual increases in runoff during the 2020s compared to the 1990s, based on the global climate models. The annual volume of flow in the Williamson River is expected to increase by approximately 8 percent, with increases of approximately 22 percent during December through March and decreases of approximately 3 percent during April through July (Reclamation 2011). The Klamath River below Iron Gate Dam is expected to experience an approximate 5 percent increase in annual flow volume, with increases of approximately 30 percent during December through March and decreases of approximately 7 percent during April through July (Reclamation 2011).

The apparent contradiction between decreasing snow-water equivalent and increasing runoff is resolved by projections suggesting a greater proportion of precipitation will fall as rain instead of snow, and the increase in overall precipitation will be greater in the winter than in the summer.

The USGS has modeled potential responses to climate change in the Sprague River Basin using several global climate models and carbon emissions scenarios (Markstrom et al. 2011, Risley et al. 2012). The models simulated the effects of climate change between 2000 and 2100 compared to a 12-year baseline period of water years 1988 through 1999. The results indicate steady increases in temperature and substantial variability with regard to future precipitation, streamflow, evapotranspiration, and groundwater flow. Projected results for the Sprague River basin for the decade between 2010 and 2020 under the most likely carbon emission scenarios have been estimated, based on the overall 2000 through 2100 simulations and include:

- An increase in mean maximum temperature ranging from approximately 0.36° to 0.54° F (0.20° to 0.35° C).
- An increase in mean minimum temperature ranging from approximately 0.18° to 0.81° F (0.10° to 0.45° C).

- A change in mean precipitation ranging from near zero to an increase of approximately 1 in (2.54 cm) per year.
- A change in mean surface water runoff ranging from near zero to an increase of approximately 4 cfs (0.11 m^3/sec).
- A change in mean streamflow ranging from near zero to an increase of approximately 60 cfs (1.7 m^3/sec).
- A change in mean groundwater flow ranging from a decrease of approximately 4 cfs (0.1 m^3/sec) to an increase of approximately 25 cfs (0.7 m^3/sec).
- A change in mean evapotranspiration ranging from a decrease of approximately 0.15 in (.37 cm) per year to an increase of approximately 0.8 in (2.0 cm) per year.
- A shift in peak streamflow over the course of the 21st Century from mid–April to early– or mid–March.

In addition to having multiple hydrologic effects, climate change may affect biological resources in the Klamath Basin. Climate change could exacerbate existing poor habitat conditions for fish by further degrading water quality. Higher water temperatures are of concern in UKL because the weather conditions documented during the last three fish die-offs in the lake were characterized by higher than average temperatures (77 FR 73740), suggesting that temperature plays a key role in the events. Because UKL is shallow, water temperatures tend to closely follow air temperatures; even a week of high air temperatures will increase water temperatures in the lake (Wood et al. 2006).

Higher water temperatures could have multiple adverse effects on suckers including: (1) Extending the growing season for AFA, perhaps leading to higher AFA biomass; (2) stressing AFA earlier or later in the season, causing more frequent bloom collapses that could affect water quality later in the season; (3) increasing respiration rates of microorganisms, thus elevating DO consumption in the water column and in sediments; (4) raising respiration rates for suckers and other fish, making it more difficult for them to obtain sufficient DO; and (5) reducing the DO holding capacity of water, which is highest in cold water. The productivity of UKL and sucker growth rates might increase as a result of higher temperatures, but if higher temperatures lead to reduced water quality, the benefits could be negated. Because of the complex nature of the lake ecosystem, it is difficult to predict what ecological changes are likely to occur as climate warms. However, it seems likely that most of the effects will be negative, and therefore will likely exacerbate the current seasonally poor habitat conditions.

Although the greatest effects of climate change on LRS and SNS habitat conditions are likely to be decades away, some effects could occur during the term of this consultation.

7.10 Habitat Conditions and Status of the Species within the UKL Recovery Unit

The Upper Klamath Lake Recovery Unit encompasses most of the occupied range of the LRS and the SNS, including UKL and the Klamath River downstream to Iron Gate Dam. Listed suckers do not occur downstream of Iron Gate Dam. The only habitats occupied by the LRS and the SNS that are not included in the action area are tributaries of the UKL (i.e., Sprague, Williamson, and Wood Rivers).

The UKL Recovery Unit is subdivided into four management units: (1) UKL river-spawning individuals; (2) UKL spring-spawning individuals (LRS only); (3) the Keno Reservoir Unit, including the area from Link River Dam to Keno Dam; and (4) the reservoirs along the Klamath River downstream from Keno Dam, known as the Klamath River Management Unit.

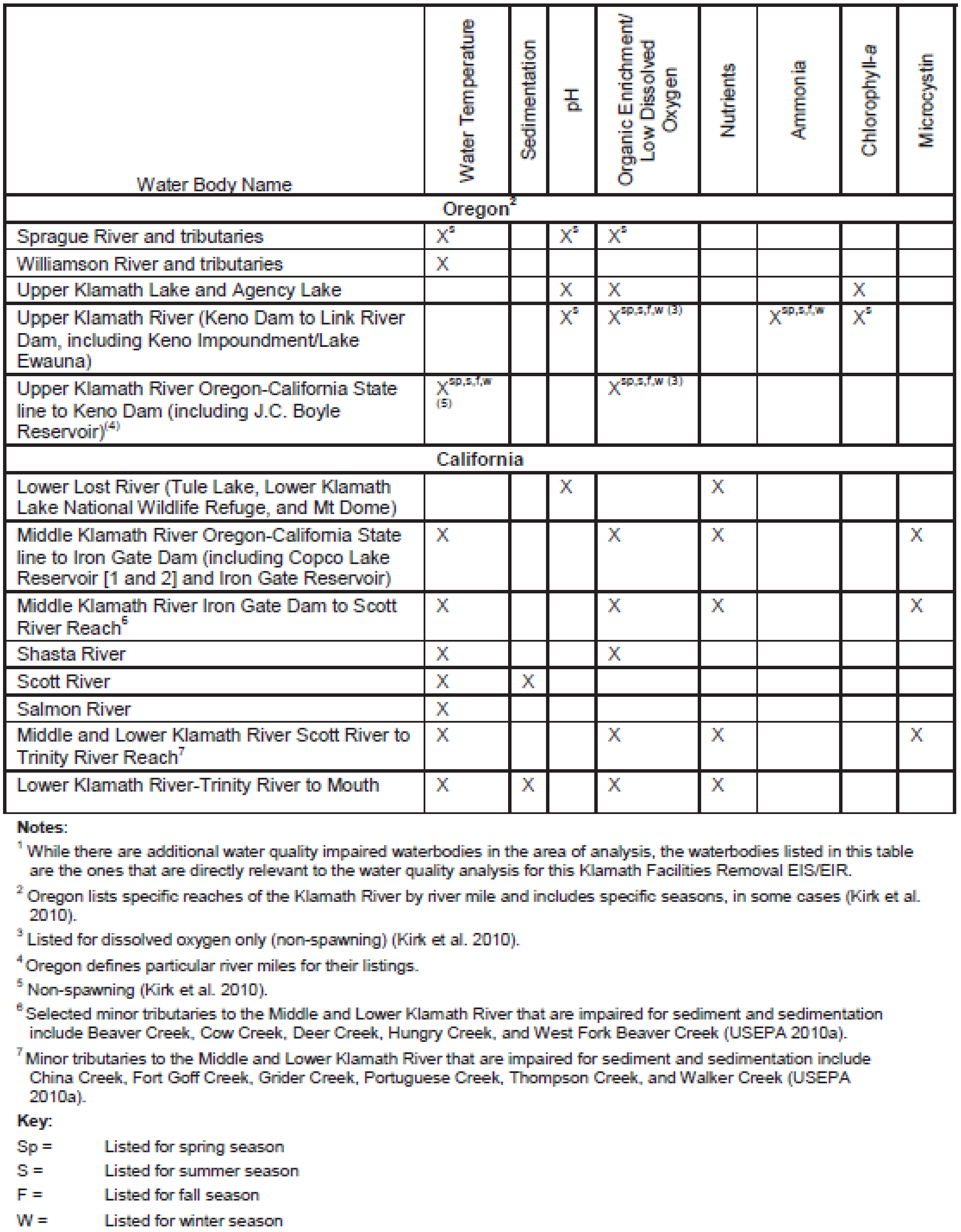
UKL is critically important to these species because it supports a large population of the SNS and the largest population of the LRS, and is the primary rearing habitat for all life stages in the sub-basin (USFWS 2013). Keno Reservoir and the Klamath River reservoirs lack suitable conditions for self-sustaining sucker populations and thus are viewed as sink populations; nonetheless they are important for recovery because they provide population redundancy, and also could be used to repopulate lost populations if they can be effectively caught. All populations of the LRS and the SNS below UKL are considered to be derived from dispersal/entrainment from UKL and thus are identified as sink population (USFWS 2008, 2013).

The major threats to the LRS and the SNS conservation in the UKL recovery unit are poor water quality (i.e., high pH and ammonia, low DO, and algal toxins), associated disease and parasites, inadequate water levels, and entrainment into agricultural diversions, especially at the Link River Dam and nearby A Canal (USFWS 2013). These threats mostly affect resiliency of the LRS and the SNS populations by reducing their abundance and productivity, but also as sucker populations are diminished in abundance, redundancy is threatened because smaller populations are at a higher risk of extirpation. The major threat to LRSs and SNSs in areas downstream from UKL is water quality, which is extremely poor in the summer (ODEQ 2010).

7.10.1 Water Quality

Section 303(d) of the Clean Water Act requires States to identify water bodies that do not meet water quality objectives and are not supporting their designated beneficial uses. Much of the Klamath basin is currently listed as water-quality impaired under section 303(d) of the Clean Water Act (Table 7.2). As such, total maximum daily loads (TMDLs) have been developed by Oregon, California, and the U.S. Environmental Protection Agency (USEPA) for specific impaired water bodies, with the intent to protect and restore beneficial uses of water. TMDLs estimate a water body's capacity to assimilate pollutants without exceeding water quality standards and set limits on the amount of pollutants that can be added and still protect identified beneficial uses. Additional information regarding Oregon TMDLs can be found on the Oregon Department of Environmental Quality (ODEQ) website (http://www.deq.state.or.us/WQ/TMDLs/klamath.htm) and California TMDLs on the North Coast Regional Water Quality Control Board (NCRWQCB) website (http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/index.shtml).

Table 7.2 Impaired water bodies within the action area (USDOI and CDFG 2012; Table 3.2-8).



Water Body Name	Water Temperature	Sedimentation	pH	Organic Enrichment/ Low Dissolved Oxygen	Nutrients	Ammonia	Chlorophyll-a	Microcystin
Oregon[2]								
Sprague River and tributaries	X[5]		X[5]	X[5]				
Williamson River and tributaries	X							
Upper Klamath Lake and Agency Lake			X	X			X	
Upper Klamath River (Keno Dam to Link River Dam, including Keno Impoundment/Lake Ewauna)			X[5]	X sp,s,f,w (3)		X sp,s,f,w	X[5]	
Upper Klamath River Oregon-California State line to Keno Dam (including J.C. Boyle Reservoir)(4)	X sp,s,f,w (5)			X sp,s,f,w (3)				
California								
Lower Lost River (Tule Lake, Lower Klamath Lake National Wildlife Refuge, and Mt Dome)			X		X			
Middle Klamath River Oregon-California State line to Iron Gate Dam (including Copco Lake Reservoir [1 and 2] and Iron Gate Reservoir)	X			X	X			X
Middle Klamath River Iron Gate Dam to Scott River Reach[6]	X			X	X			X
Shasta River	X			X				
Scott River	X	X						
Salmon River	X							
Middle and Lower Klamath River Scott River to Trinity River Reach[7]	X			X	X			X
Lower Klamath River-Trinity River to Mouth	X	X		X	X			

Notes:

[1] While there are additional water quality impaired waterbodies in the area of analysis, the waterbodies listed in this table are the ones that are directly relevant to the water quality analysis for this Klamath Facilities Removal EIS/EIR.

[2] Oregon lists specific reaches of the Klamath River by river mile and includes specific seasons, in some cases (Kirk et al. 2010).

[3] Listed for dissolved oxygen only (non-spawning) (Kirk et al. 2010).

[4] Oregon defines particular river miles for their listings.

[5] Non-spawning (Kirk et al. 2010).

[6] Selected minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include Beaver Creek, Cow Creek, Deer Creek, Hungry Creek, and West Fork Beaver Creek (USEPA 2010a).

[7] Minor tributaries to the Middle and Lower Klamath River that are impaired for sediment and sedimentation include China Creek, Fort Goff Creek, Grider Creek, Portuguese Creek, Thompson Creek, and Walker Creek (USEPA 2010a).

Key:

Sp =	Listed for spring season
S =	Listed for summer season
F =	Listed for fall season
W =	Listed for winter season

The Sprague, Williamson, and Wood Rivers are tributaries to UKL, and affect its water quality because they provide inflows to the lake and downstream habitats, and transport suspended sediments, nutrients, organics, and other particulate and dissolved constituents to the lake. The major detrimental effect to suckers in the tributaries is degraded habitat due to stream and watershed alterations. The tributaries also appreciably affect suckers through the export of nutrients, especially phosphorus, and reduced inflows to UKL as a result of upstream diversions. Although they are not part of the action area, these rivers contribute to baseline conditions within the action area.

Historical activities impacting the UKL watershed and tributaries include timber harvest, agricultural development, wetland loss and alteration, loss of beavers, hydrogeomorphic alterations to watercourses and riparian zones, and water diversions (Risley and Laenen 1999, ODEQ 2002, Bradbury et al. 2004, Eilers et al. 2004, Perry et al. 2005). Although most of these activities are historical, some continue to negatively affect the UKL because they are the main causes of the increased erosion and loading of nutrients, particularly phosphorus, in the watershed (McCormick and Campbell 2007).

Lakes, especially shallow ones like UKL, which averages about 6 ft (2m) deep, can be strongly affected by their watersheds because nutrients transported into the lakes are readily available for algae growth. Nutrients in deeper lakes can be isolated from surface-dwelling phytoplankton (suspended algae) because the lakes develop a warm-water layer (thermocline), which prevents nutrients in deeper water from reaching the surface to facilitate algae growth. Additionally, diking and draining in UKL has resulted in the loss of nearly 70 percent of its fringe wetlands, and water pumped from these areas into the lake contains high concentrations of phosphorus, thus further degrading water quality (Snyder and Morace 1997, ODEQ 2002, ASR 2005). The decline in UKL water quality also affects water quality downstream in the mainstem Klamath River due to the transfer of large amounts of organic matter, with an associated high biological oxygen demand, from UKL to downstream water bodies (Doyle and Lynch 2005, Deas and Vaughn 2006, ODEQ 2010). However, this is exacerbated by discharges from two wastewater treatment facilities and untreated stormwater discharges. Massive die-offs of adult suckers occurred in UKL during the 1990s that were attributed to adverse water quality and resultant disease (Perkins et al. 2000b).

Adverse water quality directly impacts the LRS and the SNS resiliency by decreasing survival and productivity. Adverse water quality indirectly affects the LRS and the SNS through algal toxins and interactions with pathogens, parasites, predators, and competitors that are either more tolerant of impaired water quality than suckers or benefit from the conditions created by nutrient enrichment. Based on water quality criteria examined by Morace (2007) and Martin (USGS, pers. comm., 2012), suckers are exposed to multiple stressors simultaneously or at least over a period of weeks, and water quality stress could last for several months, most often from July through September. This is most likely to affect age-0 juvenile suckers because they start appearing in July when conditions can be poor and have limited ability to move the distances that might be necessary to avoid adverse conditions. Adult suckers can move into Pelican Bay, and thus have the potential to avoid poor water quality (Perkins et al. 2000b, Banish et al. 2009). However, adults cannot always avoid stressful conditions, as the die-offs in the 1990s seem to suggest (Perkins et al. 2000b).

Table 7.3 Seasonal comparisons of potential threats to LRS and SNS in UKL from water quality parameters, including microcystin.

Water Quality Constituent	June-September	October	November-May
Low DO	A high threat	Possibly a threat	Not a threat
High Total Ammonia	A high threat	Possibly a high threat	Possibly a high threat
High pH	A threat	Not a threat	Not a threat
High Temperatures	A low threat	Not a threat	Not a threat
High Microcystin	Possibly a high threat	Possibly a threat	Possibly a threat

7.10.1.1 Water Temperature

Water temperatures in the Klamath Basin vary seasonally and by location. In the Upper Klamath Basin, water temperatures are typically very warm in summer months as ambient air temperatures heat surface waters. Water temperatures (measured as 7-day average maximum values) in UKL and much of the reach from Link River Dam to the Oregon-California border exceed 68 °F (20 °C) in June through August (ODEQ 2010), but water temperature in UKL rarely exceeds any threshold value, and therefore by itself is not currently a threat to suckers. Both UKL and the Keno Reservoir/Lake Ewauna undergo periods of intermittent, weak summertime stratification, but water temperatures in these water bodies are generally similar throughout the water column, and among the warmest in the Klamath Basin (peak values >77 °F [>25 °C]).

Temperatures within the upper Klamath Basin have been reported as increasing (Flint and Flint 2012) and decreasing (Jassby and Kann 2010), but there are many locations throughout the basin that are influenced by groundwater springs, such as the Wood River and the mainstem Klamath River downstream of J.C. Boyle Dam. These sites generally have relatively constant water temperatures year-round, and can be 41 to 59 ºF (5 to 15 ºC) cooler than other local water bodies during summer months, depending on the location. Water temperatures in the Sprague River have increased on average about 3.1 ºF (1.7 ºC) since the 1950–1999 baseline (Flint and Flint 2012), and thus temperature could pose more of a threat in the future. Increasing temperature has many potential effects, including reducing DO concentrations, increasing total ammonia-nitrogen, increasing growth rates of pathogens, and requiring greater energy demands from fish, and thus is an exacerbating factor.

7.10.1.2 Dissolved Oxygen

Dissolved oxygen (DO) concentrations within water depends on several factors, including water temperature (colder water absorbs more oxygen), water depth and volume, stream velocity (as related to mixing and re-aeration), atmospheric pressure, salinity, and the activity of organisms that depend upon dissolved oxygen for respiration. Respiratory consumption is strongly influenced by the availability of nitrogen and phosphorus for supporting algal and aquatic plant growth. According to lab studies, LRS and SNS larvae and juveniles begin dying when DO concentrations reach about 2 mg/L, and by about 1.5 mg/L most suckers die (Martin and Saiki 1999). The lethal DO threshold for adult suckers is unknown, but likely is similar to juveniles.

In tributaries to UKL, limited data indicate that DO varies from greater than 7 to 13 mg/L (ODEQ 2002). Concentrations in the lakes within the recovery unit exhibit seasonal and spatial variability, ranging from less than 4 mg/L to greater than 10 mg/L. Water quality datasets collected by the Klamath tribes include weeks during the summer months when DO levels in UKL are consistently below the ODEQ criterion of 5.5 mg/L for support of warm-water aquatic life (Kann 2010). Low (0 to 4 mg/L) DO concentrations occur most frequently in August, the period of declining algal blooms and warm water temperatures in the lake (Walker 2001, ODEQ 2002). Morace (2007) provided a detailed review of DO concentrations in UKL, based on 17 years of data (1990–2006), and Jassby and Kann (2010) conducted a similar review based on an additional 3 years (1990–2009) of data collection.

Downstream in Keno Reservoir, DO reaches very low levels (< 1 to 2 mg/L) during July and October as algae transported from UKL settle out of the water and decay. Persistent low DO events in this reach, where the DO remains less than 2 mg/L, can last for several days or even weeks. Decomposition of algae transported from UKL appears to be the primary driver of low oxygen in the Keno Reservoir. Two water treatment facilities discharge treated wastewater to the Keno Reservoir; however, these facilities contribute a very small amount (<1.5 percent of the organic material loading) to the overall oxygen demand in the Keno reach. Organic matter and nutrient inputs, which promote primary productivity, from the Lost River basin via the Klamath Straits Drain and the Lost River Diversion Channel also contribute to low DO levels in this reach (Sullivan et al. 2009, ODEQ 2010, Sullivan et al. 2011).

During summer, the reservoirs in the Klamath Hydroelectric Reach exhibit varying degrees of DO super-saturation (i.e., >100 percent saturation) in surface waters (due to high rates of internal photosynthesis by algae) and oxygen depletion in bottom waters (due to microbial decomposition of dead algae). Although J.C. Boyle Reservoir, a relatively long shallow reservoir, does not stratify, large variations in DO are observed at its discharge due to high oxygen demand from water conditions in the upstream reach from Link River Dam through the Keno Reservoir, and in UKL. Copco 1 and Iron Gate Reservoirs thermally stratify beginning in April/May and do not mix again until October/November (FERC 2007). DO in Iron Gate and Copco 1 surface waters during summer months is generally at or, in some cases, above saturation, while levels in hypolimnetic waters reach minimum values near 0 mg/L by July (Raymond 2008, 2009, 2010).

7.10.1.3 Ammonia Toxicity

Low DO events are often associated with high levels of un-ionized ammonia, which is toxic to fish at concentrations above 0.5 mg/L (Saiki et al. 1999, PacifiCorp 2004, Deas and Vaughn 2006, ODEQ 2010, Sullivan et al. 2011). Ammonia toxicity is complex because it is a function of both pH and temperature, and is most toxic at higher pH (USEPA 2009). At a pH above 8, ammonia toxicity is mostly due to un-ionized ammonia, but below pH 8 toxicity is based on total ammonia concentrations. Saiki et al. (1999) reviewed the results of a variety of tests using ammonia alone and in conjunction with pH, DO, and temperature to assess how ammonia affected survival of larval and juvenile suckers, and found that median LC_{50} (the concentration of ammonia that is lethal to 50 percent of test individuals) values for un-ionized ammonia varied from 0.48–1.29 mg/L for 96 hour exposures for larval and juvenile suckers. Meyer and Hansen (2002) concluded that the LC_{50} for indefinite exposure of LRS early life stages to un-ionized ammonia is approximately 0.5 mg/L.

B. Martin (USGS, pers. comm., 2012) reviewed water quality data for UKL to determine water quality associated risks. Data from approximately 3,800 samples were analyzed for DO, pH, temperature, and total ammonia-nitrogen using data collected by the Klamath tribes and USGS since 1991. The results showed that the total ammonia-nitrogen concentrations were at threshold values for the suckers in most years, suggesting this compound is a noteworthy threat to the LRS and the SNS in UKL. DO concentrations rarely exceeded the LC_{50} value, but about 10 percent were about at the 4.0 mg/L stress threshold. pH values also rarely exceeded the LC_{50} value of 10.3, but about 15 percent exceeded the high stress level of pH 9.75.

Keno Reservoir is currently listed as impaired year-round for ammonia toxicity under section 303(d) of the Clean Water Act (ODEQ 2010). In the 2010 TMDL for the Oregon portion of the Klamath River that includes the Keno Reservoir, ODEQ (2010) described ammonia concentrations, which peak at Miller Island (RM 245) in July and August. Total ammonia nitrogen concentrations in the Keno Reservoir frequently exceed Oregon's chronic criteria from June to September, and can exceed the acute criteria in both June and July (ODEQ 2010). These degraded conditions can occur throughout much of the 20 mile long reservoir, with better conditions only in the uppermost and lowermost reaches. Fish die-offs in the Keno Reservoir occur in most summers (USFWS 2008).

7.10.1.4 Nutrients

Primary plant nutrients, including nitrogen and phosphorus, are affected by the geology of the surrounding watershed of the Klamath River, upland productivity and land uses, and a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. Nitrogen arriving in UKL has been attributed to upland soil erosion, runoff, and irrigation return flows from agriculture, as well as *in situ* nitrogen fixation by cyanobacteria, especially AFA (ODEQ 2002). Although the relatively high levels of phosphorus present in Upper Klamath Basin volcanic rocks and soils have been identified as a major contributing factor to phosphorus loading to the lake (ODEQ 2002), land use activities in the Upper Klamath Basin have also been linked to increased nutrient loading (Snyder and Morace 1997, Kann and Walker 1999, Bradbury et al. 2004, Colman et al. 2004, Eilers et al. 2004), subsequent changes in trophic status, and associated degradation of water quality. Extensive monitoring and research conducted for development of the UKL TMDLs (ODEQ 2002) show that the lake is a major source of nitrogen and phosphorus loading to the Klamath River. Nutrient and organic matter inputs from the Lost River Basin via Klamath Straits Drain and the Lost River Diversion Channel are also an important source of nutrients to the Upper Klamath River (Figure 7.5; Sullivan et al. 2009, ODEQ 2010).

The operations of Keno Dam likely reduce nutrient cycling that would improve water quality in Keno Reservoir. The dam and its impoundment affect water quality primarily by increasing surface area, hydraulic retention time, and solar exposure (FERC 2007). The longer residence time allows temperatures to increase and facilitates photosynthetic and microbial processes that further degrade water quality.

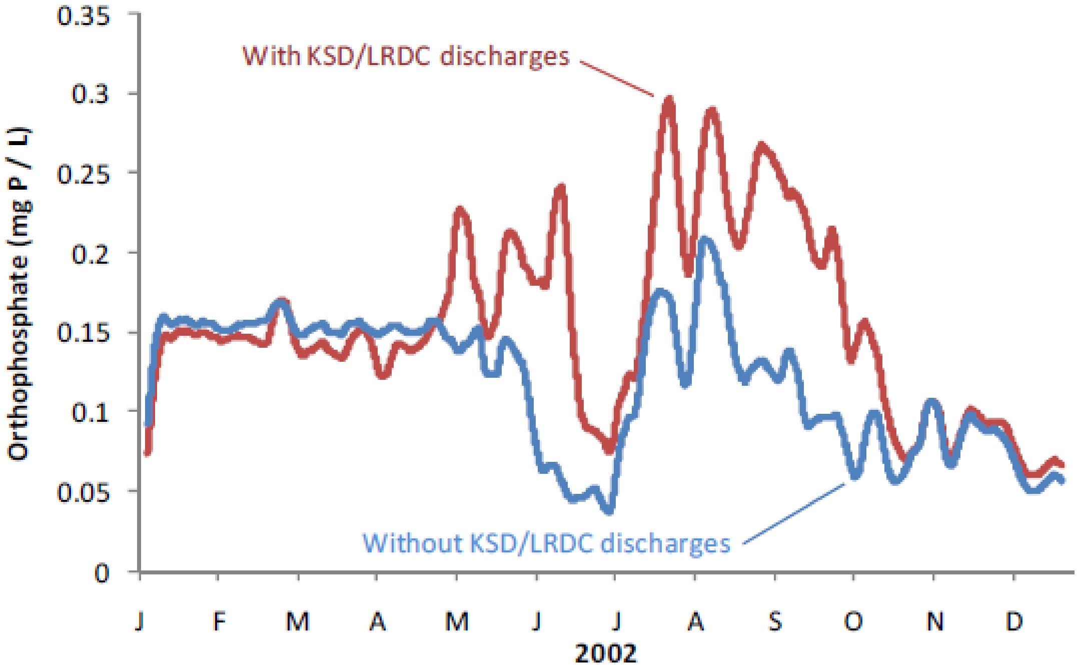


Figure 7.5 Model results of orthophosphate concentrations from just downstream of Klamath Straits Drain discharge. The "With Klamath Straits Drain/Lost River Diversion Channel" results are from the 2002 calibration model (ODEQ 2010).

Excessive phosphorus loading linked to watershed development has been determined to be a key factor driving the massive AFA blooms that now dominate UKL in the summer (ODEQ 2002, NRC 2004). UKL was eutrophic prior to settlement by Anglo-Americans, but is now classified as being hypereutrophic (highly enriched; ODEQ 2002, Bradbury et al. 2004, Eilers et al. 2004), due in large part to human manipulations. Riparian and floodplain habitats, which can detain or alter nutrients throughout the system, have been lost or degraded as a result of ditching and diking to promote drainage and prevent overbank flows. The relatively high runoff and erosion in the Sprague River drainage during high flow events have been identified as the major source of bound phosphorus to UKL, but many external sources contribute to the nutrient loading of UKL (ODEQ 2002). Ecosystem improvement efforts are implemented regularly to reduce nutrient loading due to development and land management, but it is unclear to what degree restoration can reduce nutrient availability because UKL sediments contain large amounts of phosphorus that continue to support AFA blooms from sources within the lake (NRC 2004; Kuwabara et al. 2007, 2009).

Table 7.4 Estimated external phosphorus loading to UKL from various sources (ODEQ 2002).

Source Area	Percent of Drainage Area	Percent of Inflow to UKL	Percent of External Phosphorus Load
Sprague River	43	33	26
Williamson River	36	18	20
Wood River	4.0	16	19
Seven Mile Creek	1.1	6.5	9.0
Agricultural Discharges Directly into UKL	1.1	2.9	11
Precipitation Input Directly into UKL	2.8	7.0	2.7
Other Sources	16	14	11

7.10.1.5 pH

Because the Klamath River is a weakly buffered system (i.e., has typically low alkalinity <100 mg/L; PacifiCorp 2004, Karuk Tribe of California 2010), it is susceptible to photosynthesis-driven daily and seasonal swings in pH. In the Upper Klamath Basin, summertime pH levels are elevated above neutral (i.e., up to 8.2 in the Wood River subbasin and 8.5 to 9.5 in the Sprague River). These elevated pH levels have been linked primarily to high rates of photosynthesis by periphyton (ODEQ 2002). During November to April, pH levels in UKL are near neutral (Aquatic Scientific Resources 2005), but increase to very high levels (>10) in summer. Extended periods of pH greater than 9 have been associated with large summer algal blooms in UKL (Kann 2010). On a daily basis, algal photosynthesis can elevate pH levels by up to 2 pH units over a 24-hour period. Generally, pH in the reach from Link River Dam through the Keno Reservoir increases from spring to early summer and decreases in the fall; however, there are site-dependent variations in the observed trend. Peak values can exceed the Oregon Department of Environmental Quality maximum of 9.0.

7.10.1.6 Algae

In UKL, algae, including blue-green algae, are dominated by large summertime blooms of AFA. High (i.e., near 300 µg/L) summer chlorophyll-*a* concentrations in the Keno Reservoir/Lake Ewauna are due to large populations and associated nutrients of algae, predominantly AFA, entering the Klamath River from UKL in summer (FERC 2007; Sullivan et al. 2008, 2009, 2011). Such high concentrations do not persist farther downstream in J.C. Boyle Reservoir; however, chlorophyll-*a* concentrations increase again in the two largest reservoirs (i.e., Copco 1 and Iron Gate) in the Klamath Hydroelectric Reach. Seasonal algal blooms and elevated chlorophyll-*a* concentrations have been observed in the Klamath Hydroelectric Reach historically, including a USEPA survey in Iron Gate Reservoir in 1975 that documented algal blooms in March, July, and October, including diatoms and blue-green algae). More contemporary data indicates that chlorophyll-*a* levels in Copco 1 and Iron Gate Reservoirs can be 2 to 10 times greater than those documented in the mainstem river, although not as high as those found in the Keno Impoundment/Lake Ewauna (NCRWQCB 2010).

Some cyanobacteria species produce cyanotoxins (e.g., cyclic peptide toxins, such as microcystin, that act on the liver; alkaloid toxins such as anatoxin-a and saxitoxin, that act on the nervous system), which can cause irritation, sickness, or, in extreme cases, death to exposed organisms, including humans (World Health Organization 1999). Species capable of producing microcystin include *Microcystis aeruginosa*, while species in the genus *Anabaena* and AFA can produce anatoxin-a and saxitoxin, but assays of AFA in UKL indicate that the strain in this lake do not produce these toxins (Carmichael et al. 2000).

Algal toxins represent a potentially serious threat to suckers in UKL (VanderKooi et al. 2010, Eldridge et al. 2012), especially microcystin, a liver toxin produced by the cyanobacterium *M. aeruginosa*. Microcystin likely enters suckers through the gut as they consume midge larvae containing the toxin (VanderKooi et al. 2010, Rosen et al. 2011, Eldridge et al. 2012). Microcystins are actively taken up by the liver in fish where they disrupt normal cellular activity by inhibiting protein phosphatases, and can ultimately result in widespread cellular death, loss of liver structure, and mortality (Malbrouck and Kestemont 2006, California Environmental Protection Agency (CEPA 2009). Due to the limited capacity of fish to detoxify microcystins, they easily succumb to the toxic effects of elevated microcystin concentrations (Malbrouck and Kestemont 2006, CEPA 2009). Additional sublethal effects of microcystins include reduced growth rates and osmoregulation, modified behavior, reduction in immune system and cardiac function, and histopathological effects in other organs (e.g., intestine, kidneys, heart, spleen, or gills; Malbrouck and Kestemont 2006, CEPA 2009). Because microcystin is relatively stable, persisting *in situ* for months (CEPA 2009), it potentially could accumulate in fish tissues and have continued adverse effects through the winter (Malbrouck and Kestemont 2006). Microcystin can also bioaccumulate in aquatic biota (Malbrouck and Kestemont 2006).

Age-0 suckers could be at a greater risk of harm than adult suckers by microcystin because young life stages of fish are known to be generally more sensitive to toxic compounds (Malbrouck and Kestemont 2006). Additionally, the mobility of juvenile suckers is limited compared to adults, and juveniles are often found in shallow areas where wind-blown cyanobacteria can accumulate, thus exposing them to microcystin.

Microcystin was first reported in UKL in 1996, when an investigation showed significant microcystin levels in the lake (Gilroy et al. 2000). In 2007 and 2008 microcystin concentrations reached levels peaked at 17 µg/L, which is greater than the World Health Organization limit for drinking water (1 µg/L) and above the Oregon Department of Public Health guidelines for issuing public health advisories (VanderKooi et al. 2010, Eldridge et al. 2012). In 2007, examination of juvenile suckers from UKL showed that nearly 50 percent had liver and gastrointestinal damage consistent with microcystin exposure (VanderKooi et al. 2010, Densmore et al. 2011, Eldridge et al. 2012).

7.10.1.7 Impacts of Water Quality and Algal Toxins on LRS and SNS

As stated above, the Sprague and Williamson Rivers are listed as impaired under the Clean Water Act for water temperature and the Sprague River is also listed as impaired for pH and DO. These designations of impairments are only during the summer and so it is unlikely that these impairments directly affect the listed suckers, since the fish are only present during the spawning and outmigration period, which concludes before summer.

The impacts of water quality and algal toxins on suckers in UKL are complex and incompletely understood. Large fish die-off events, although uncommon, can have a pronounced effect on population resiliency by killing numerous adults and could affect redundancy by eliminating entire populations. For example, there were three consecutive fish die-offs in UKL (1995–1997) that possibly involved tens of thousands of adult suckers (Perkins et al. 2000b). Multiple factors were likely to blame, but low DO concentrations and perhaps high total ammonia-nitrogen concentrations were implicated in the die-offs (Perkins et al. 2000b). During the die-off period in 1996 there was concurrently a *M. aeruginosa* bloom, which may have been a contributing factor.

Although massive die-offs appear linked to extremes in water quality (Perkins et al. 2000b), the impacts of normal annual variations in water quality and algal toxins on sucker populations are even less well understood. This is especially pertinent to the putative universal disappearance of juvenile suckers from UKL beginning in August and extending into October (Simon et al. 2011). Because stressful water quality conditions occur during this same time period (Morace 2007, Eldridge et al. 2012, B. Martin, USGS, pers. comm., 2012); it is likely that the unnaturally high rates of age-0 sucker mortality are tied to adverse water quality, including microcystin concentrations, although other factors, including parasites, entrainment, and predation are also likely involved, and it is unclear whether the effects from water quality are acute or chronic.

The fact that water quality and microcystin concentrations are highly variable temporally and spatially in UKL (Morace 2007, Eldridge et al. 2012, B. Martin, USGS, pers. comm., 2012) suggests that these factors might not be directly responsible for the annual disappearance of age-0 LRS and SNS. In other words, the variability would produce patchiness in space and time that would possibly provide adequate conditions for survival of some individuals. However, chronic or synergistic effects between water quality and predation, disease, and parasites could cause the high levels of mortality that explains the annual loss of nearly all age-0 juveniles. For example, predation rates of juvenile suckers by birds might increase as a result of adverse water quality conditions and microcystin toxicosis, and parasites could also increase bird predation rates, as discussed below. Possible evidence that this occurs comes from aggregations of fish-eating birds, including terns, gulls, and pelicans that occur in UKL and the Keno Reservoir when water quality conditions are poor. Furthermore, entrainment at the A canal increased during periods of poor water quality in 1997 and 1998 (Gutermuth et al. 2000a, b). Although the annual effect of poor water quality and algal toxins appears to primarily affect age-0 juveniles, adult suckers could also be adversely affected through stress, energy loss, reduced feeding, and lowered resistance to parasites and disease; however, with their larger energy reserves they apparently have much higher survival rates than juveniles.

The low numbers of suckers in Keno Reservoir can be attributed to poor water quality in the summer (Piaskowski 2003). DO levels reach stressful and lethal levels for suckers during July and August (Piaskowski 2003, Deas and Vaughn 2006, Reclamation 2007). Fish die-offs, including juvenile suckers, are a regular occurrence in Keno Reservoir (Tinniswood 2006). There are few, if any, refugial areas in Keno Reservoir and several major diversions from the water body could serve as emigration corridors (Bennetts 2005, Foster and Bennetts 2006b, Reclamation 2007) for individuals during poor water quality, effectively removing individuals from the population.

7.10.2 Upper Klamath Lake and Tributaries Water Quantity and Trend Analyses

The volume of water available in UKL at any one time is based in part on a variety of weather and climate factors including the amount and timing of precipitation, the percentage of precipitation occurring as snow versus rain, snow–water equivalent, air temperature, wind speed and direction, and relative humidity among others. Anthropogenic actions such as groundwater pumping and surface water diversions in areas tributary to the lake, or from the lake itself, also affect the available volume of water. For the purposes of this BiOp, these factors are not described individually because they are expressed jointly as the net inflow of water to UKL. Direct measurement of flow into UKL is not possible; therefore, net inflow is calculated based on the change in storage in the lake (change in the volume of water in the lake) and measured outflow.

Net Inflow = Change in lake storage + measured outflow

Annual net inflow to UKL during the period of record ranged from a low of 596,000 acre-feet (1992) to a high of 1,978,000 acre-feet (1984). The average and median annual net inflows during the period of record are 1,246,000 and 1,114,000 acre-feet, respectively. Approximately 47 percent of the annual inflow occurs between October and February, 44 percent between March and June, and 9 percent between July and September.

The change in storage is calculated based on a weighted average of lake surface elevation at three widely spaced gages and an elevation-capacity relationship (Appendix A). Outflow from the lake is measured on the Klamath River below the Link River Dam and at the A Canal diversion. Losses from evaporation and gains from direct precipitation and groundwater discharge into the lake are not measured; however, these losses and gains are manifested in the change in storage.

The primary subbasins draining into UKL are the Sprague, Williamson, and Wood River basins. The Sprague River flows into the Williamson River near Chiloquin, Oregon, several miles above the point where the Williamson River flows into UKL. There is a very strong relationship between flow in the Williamson River below its confluence with the Sprague River and net inflow to UKL (Garen 2011). Therefore, evaluation of trends in net inflow is enhanced by understanding trends in flow in the Sprague and Williamson Rivers.

Evaluation of baseline hydrology involved analyses of data for UKL and the Sprague and Williamson Rivers. Even though the proposed action was developed based on the 1981 through 2011 period of record (2012 data were not available when the proposed action was developed), data from water year 2012 and years before 1981 were incorporated into the baseline hydrology evaluation where applicable. Data sets used for hydrologic analysis included daily observed flow data for water years 1921 through 2012 in the Sprague River, 1918 through 2012 in the Williamson River, and 1981 through 2012 in UKL.

The daily data were reduced to median monthly values for seasonal time frames. Median flow values for each season were calculated from the daily flow values for that season for each year during the period analyzed. For example, the median for the October through February period was calculated based on 151 daily flow values (data for February 29 were excluded). For the March through June period, the median was calculated based on 122 daily flow values. For July through September, the median was calculated based on 92 daily flow values, and for the water year it was based on 365 daily flow values.

Trends in median seasonal and water year flow in the Sprague and Williamson rivers and net inflow into UKL were evaluated by fitting a LOcally WEighted Scatterplot Smoothing (LOWESS) curve (Helsel and Hirsch 2002) to flow data, and statistical testing for trend using the Mann-Kendall trend test (Helsel and Hirsch 2002; Helsel et al. 2005). Trends were evaluated based on the entire period of record for each water body: water years 1921 through 2012 for the Sprague River, 1918 through 2012 for the Williamson River, and 1981 through 2012 for UKL. UKL inflow data for water years 1961 through 1980 were not used because daily calculated net inflows are not available.

LOWESS smoothing emphasizes the shape of the relationship between two sets of variables; and in this case, the variables are flow volume and time. LOWESS smoothing provides a way to evaluate changes in data without the constraint of a prior assumption of an equation that best models the data.

The Mann-Kendall method is a nonparametric trend test that determines whether a statistically significant upward or downward change in flow has occurred over the period of record. Nonparametric tests are most appropriate where data are expected to be non-normally distributed or where a specific distribution is unknown (Helsel and Hirsch 2002). The Mann-Kendall trend test is superior to simple linear regression because the Mann-Kendall test was developed specifically to determine if the median, or central value, changes over time (Helsel and Hirsch 2002). The effects of extreme values do not influence Mann-Kendall tests as substantially as they influence simple linear regression. Flow data are strongly serially correlated, which is a correlation between a value and previous values in the dataset. Although simple linear regression and the Mann-Kendall test are biased when serial correlation is present, the use of monthly medians reduces these effects substantially. In our analysis, the Mann-Kendall equations test for a monotonic trend (the dependent Y variable changes in a consistent direction) in the flow data over time (Helsel et al. 2005).

A significance level (alpha) of 0.10 was selected for assessing the Mann-Kendall trend test data. The alpha does not depend on the data, but is a management decision regarding the level of significance to be applied to the statistical test results. It is a subjective value used to evaluate the risk of concluding a statistically significant trend exists when, in fact, no significant trend exists (the risk of rejecting the null hypothesis when the null hypothesis is actually true). For example, an alpha of 0.10 states that a 10 percent risk of incorrectly concluding a trend exists is acceptable whereas an alpha of 0.01 states the acceptable risk of error is 1 percent. The p-value calculated by the Mann-Kendall test is compared to the chosen alpha value. The p-value is the probability that the statistical outcome will occur if no trend exists–it provides an assessment of the strength of the scientific evidence. Therefore, a p-value less than alpha is determined to be statistically significant (in other words, a trend exists) and a p-value greater than the alpha is determined to be not significant (no trend is detectable).

Trends in median seasonal and water year net inflow to UKL during the most recent approximate two decades (1991 through 2012 and 2001 through 2012 [22 and 12 years, respectively]) almost universally demonstrate a linear trend of increasing net inflow superimposed on shorter duration episodes of changing inflow patterns; however, the trends are not statistically significant based on the criteria discussed below. Conversely, trends in net inflow to UKL during the 1981 through 2012 (32-year) period indicate a statistically significant decline in seasonal and annual flows. When examined over multiple time frames and in more detail, trends are complex and suggest both increasing and decreasing net inflows depending on season and the specific set of years analyzed. In general, median seasonal flows in the Sprague and Williamson rivers have increased from the early 1920s through 2012. However, that trend changed in the 1940s and flows in the Sprague and Williamson Rivers exhibit an overall statistically significant decrease from the 1940s through 2012 (Tables 7.5 through 7.8).

7.10.2.1 Seasonal and Water Year Changes in Sprague and Williamson Rivers and Upper Klamath Lake Net Inflow

Percent changes in flow in the Sprague and Williamson Rivers and net inflow to UKL for various seasons over selected time periods are shown in Table 7.5 through Table 7.8. Shading indicates trends that are statistically significant at the selected alpha of 0.10. Values in un-shaded cells may indicate a trend, however, the available evidence are insufficient to conclude there is a trend within the selected significance level.

During the October through February season (Table 7.5), the most striking trend is the statistically valid decline in flows for the periods beginning in 1941, 1951, 1961, 1971, and 1981, and ending in 2012. No statistically significant trend is present in the 1991 and 2001 through 2012 periods.

Table 7.5 Percent change in October through February median monthly flows in the Sprague and Williamson Rivers and net inflow to UKL, 1918 through 2012.

Mann-Kendall Trend Test Results: October through February						
	Sprague River		Williamson River		Upper Klamath Lake	
Time Period	% change	p-value[1]	% change	p-value[1]	% change	p-value[1]
1918 or 1921 through	22.4%	0.02	7.2%	0.33	--	--

2012						
1931 through 2012	12.6%	0.24	5.4%	0.46	--	--
1941 through 2012	-12.0%	0.15	-16.4%	0.06	--	--
1951 through 2012	-26.4%	<0.01	-38.5%	<0.01	--	--
1961 through 2012	-21.6%	0.02	-30.4%	<0.01	--	--
1971 through 2012	-27.3%	0.01	-39.5%	<0.01	--	--
1981 through 2012	-21.9%	0.10	-36.8%	0.02	-31.3%	0.02
1991 through 2012	1.4%	0.96	3.3%	0.65	2.5%	0.82
2001 through 2012	-6.6%	0.37	-5.8%	0.54	-4.3%	0.54

[1] p-value indicates the probability that the change in inflow is caused by chance rather than a trend. Shading indicates the values considered statistically significant at an alpha of 0.10

During the March through June season (Table 7.6), the sole statistically valid trend is the decline in flows in the Williamson River for the period from 1951 through 2012.

Table 7.6 Percent change in March through June median monthly flows in the Sprague and Williamson Rivers and net inflow to UKL, 1918 through 2012.

Mann-Kendall Trend Test Results: March through June						
	Sprague River		Williamson River		Upper Klamath Lake	
Time Period	% change	p-value[1]	% change	p-value[1]	% change	p-value[1]
1918 or 1921 through 2012	27.7%	0.28	25.2%	0.19	--	--
1931 through 2012	16.2%	0.59	13.3%	0.52	--	--
1941 through 2012	-14.9%	0.44	-19.5%	0.25	--	--
1951 through 2012	-29.9%	0.17	-35.9%	0.02	--	--
1961 through 2012	-8.3%	0.76	-13.4%	0.51	--	--
1971 through 2012	-25.5%	0.43	-29.0%	0.16	--	--
1981 through 2012	-21.2%	0.57	-24.6%	0.29	-25.3%	0.26

1991 through 2012	-2.9%	1.00	3.8%	1.00	10.0%	0.91
2001 through 2012	62.4%	0.37	29.8%	0.37	22.1%	0.19
[1] p-value indicates the probability that the change in inflow is caused by chance rather than a trend. Shading indicates the values considered statistically significant at an alpha of 0.10						

The most conspicuous July through September trend (Table 7.7), is the statistically valid decline in flows for the almost all periods except those from 1991 through 2012. The most probable explanation for July through September declines during years when flows are increasing in other seasons is irrigation withdrawals. No statistically significant trend is present in the 1991 and 2001 through 2012 periods, except for an increasing trend in the Williamson River in the past decade.

Table 7.7 Percent change in July through September median monthly flows in the Sprague and Williamson Rivers and net inflow to UKL, 1918 through 2012.

Mann-Kendall Trend Test Results: July through September						
	Sprague River		Williamson River		Upper Klamath Lake	
Time Period	% change	p-value[1]	% change	p-value[1]	% change	p-value[1]
1918 or 1921 through 2012	-24.3%	0.01	-17.8%	<0.01	--	--
1931 through 2012	-23.1%	0.03	-15.0%	0.01	--	--
1941 through 2012	-41.5%	<0.01	-23.8%	<0.01	--	--
1951 through 2012	-51.0%	<0.01	-31.5%	<0.01	--	--
1961 through 2012	-42.6%	<0.01	-19.5%	<0.01	--	--
1971 through 2012	-47.3%	<0.01	-22.9%	0.01	--	--
1981 through 2012	-51.6%	0.02	-14.0%	0.25	-40.3%	0.09
1991 through 2012	-16.9%	0.69	14.4%	0.34	-0.5%	0.96
2001 through 2012	15.9%	0.37	19.2%	0.02	15.5%	0.11
[1] p-value indicates the probability that the change in inflow is caused by chance rather than a trend. Shading indicates the values considered statistically significant at an alpha of 0.10						

The overall water year trend (Table 7.8) is strikingly similar to the October through February season with respect to the pattern and magnitude of statistically valid trends. Both seasons suggest a trend of increasing flows in the Sprague and Williamson Rivers when the entire record is examined, and declining trends in the middle to late portions of the 20th Century. No statistically significant trend is present in the 1991 and 2001 through 2012 periods.

Table 7.8 Percent change in water year median monthly flows in the Sprague and Williamson Rivers and net inflow to UKL, 1918 through 2012.

Mann-Kendall Trend Test Results: Water Year						
	Sprague River		Williamson River		Upper Klamath Lake	
Time Period	% change	p-value[1]	% change	p-value[1]	% change	p-value[1]
1918 or 1921 through 2012	26.4%	0.01	8.6%	0.27	--	--
1931 through 2012	17.9%	0.16	4.9%	0.50	--	--
1941 through 2012	-12.9%	0.18	-17.3%	0.03	--	--
1951 through 2012	-30.0%	<0.01	-38.5%	<0.01	--	--
1961 through 2012	-20.5%	0.04	-28.9%	<0.01	--	--
1971 through 2012	-25.4%	0.03	-36.0%	<0.01	--	--
1981 through 2012	-23.3%	0.06	-30.0%	0.04	-30.1%	0.05
1991 through 2012	-8.3%	0.71	10.3%	0.38	7.1%	0.82
2001 through 2012	-5.5%	0.34	3.5%	0.68	17.5%	0.37

[1] p-value indicates the probability that the change in inflow is caused by chance rather than a trend. Shading indicates the values considered statistically significant at an alpha of 0.10

Select graphs of water year flow data, LOWESS smooths and Mann-Kendall trends for the Sprague and Williamson Rivers and UKL are presented below. Graphs of additional time periods for both water-year and seasonal flow data, smooths, and trends are included in Appendix D.

7.10.2.1.1 Sprague River

Trends in Sprague River flow for the water year are shown in Figure 7.6 through Figure 7.9. Each graph shows identical observed median monthly flow data for water years 1921 through 2012. However, the LOWESS smooth and Mann-Kendall trend test data are fit to four different periods: water years 1921 through 2012, 1981 through 2012, 1991 through 2012, and 2001 through 2012. Observed data are shown as triangles, LOWESS smooths as solid lines, and Mann-Kendall trends as dashed lines.

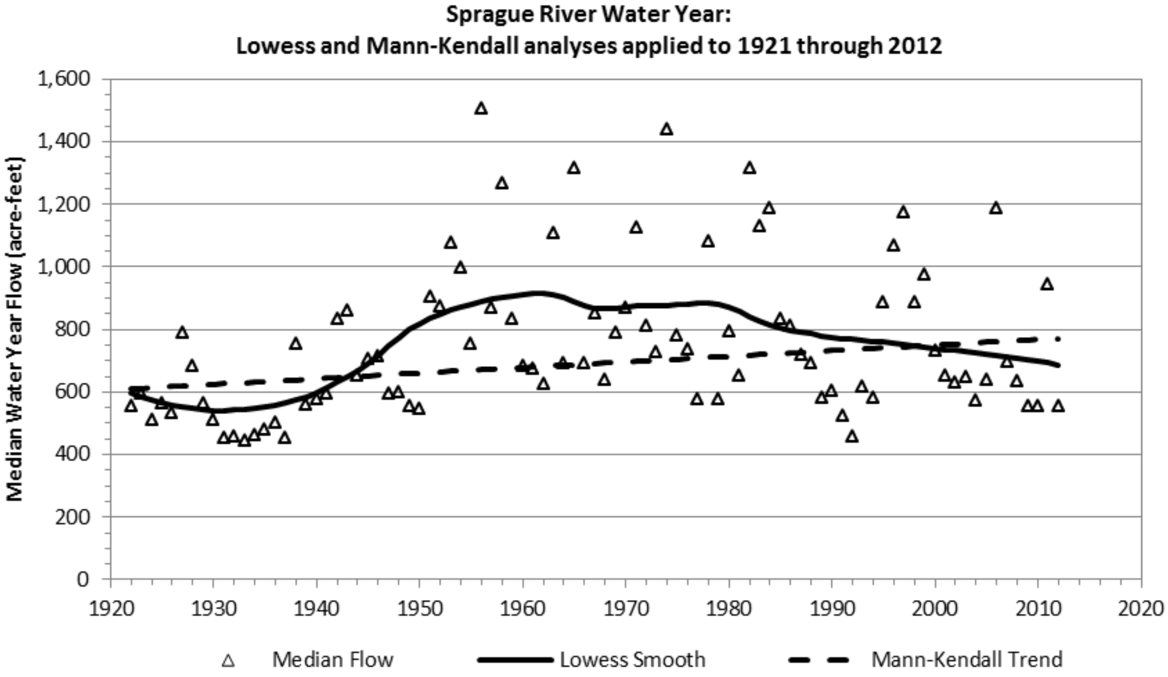


Figure 7.6 Sprague River trends, water years 1921 through 2012.

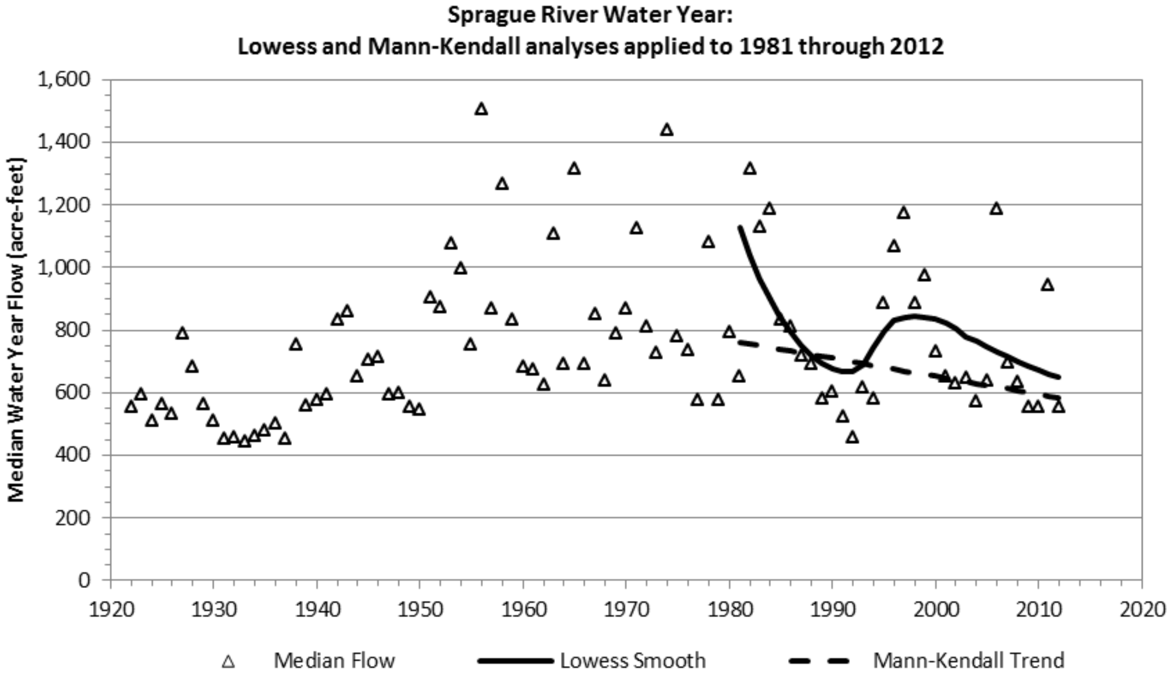


Figure 7.7 Sprague River trends, water years 1981 through 2012.

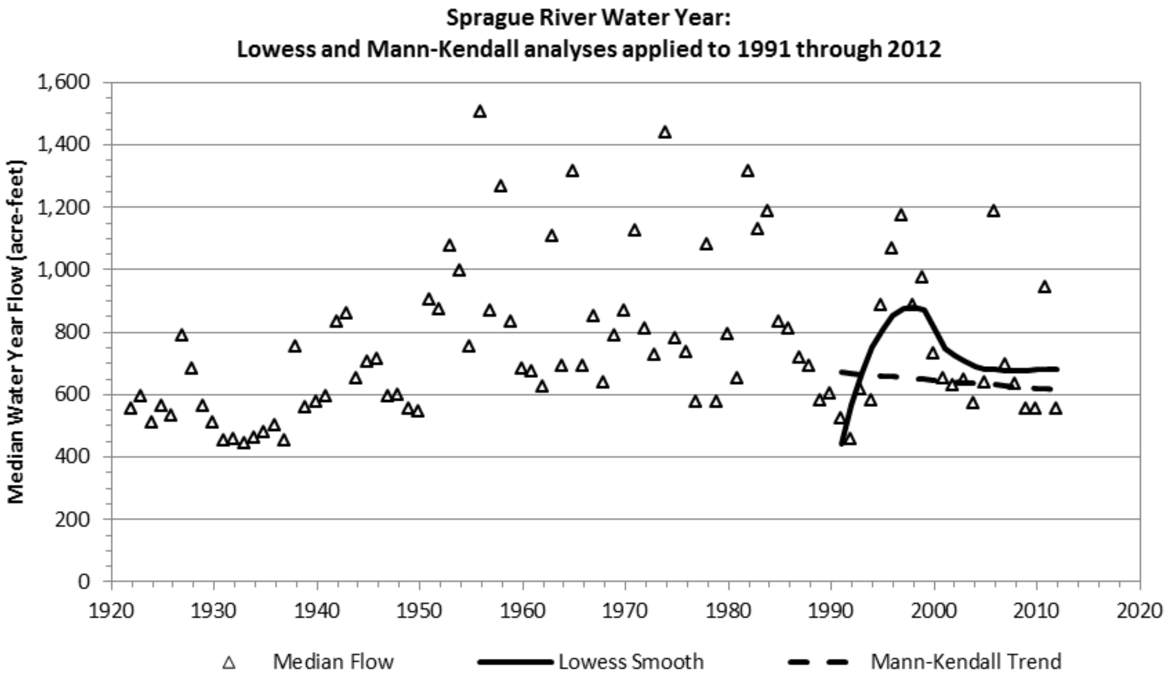


Figure 7.8 Sprague River trends, water years 1991 through 2012.

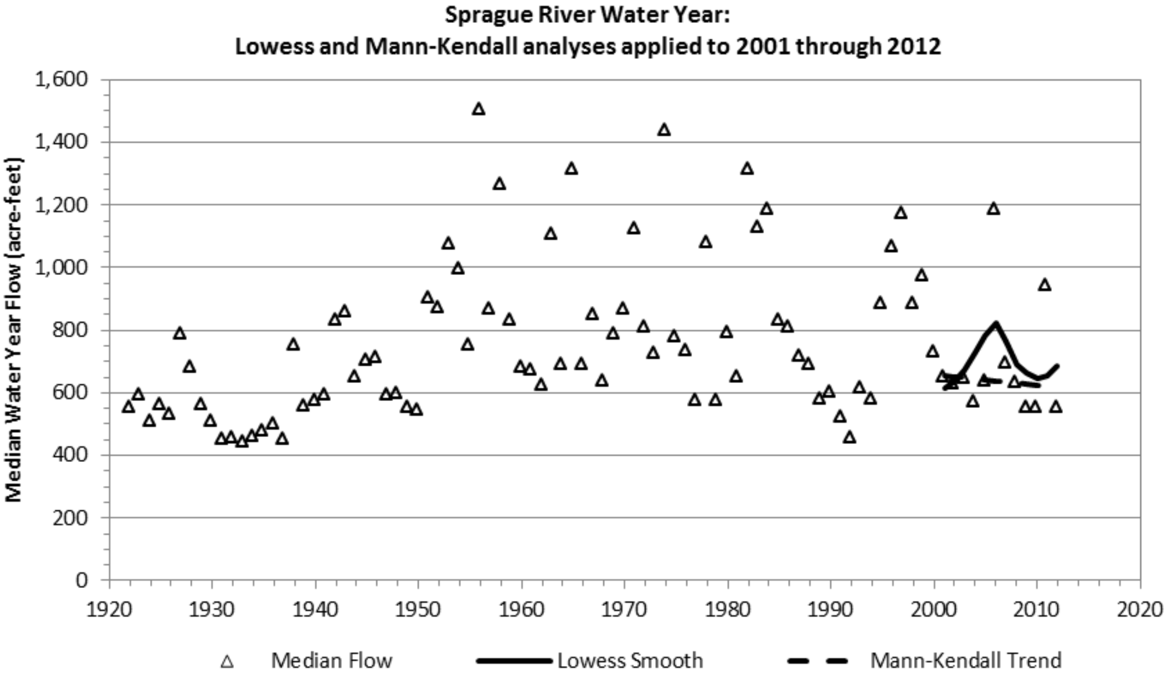


Figure 7.9 Sprague River trends, water years 2001 through 2012.

7.10.2.1.2 Williamson River

Trends in Williamson River flow for the Water Year are shown in Figure 7.10 through Figure 7.13. Each graph shows identical observed median monthly flow data for water years 1918 through 2012. The LOWESS smooth and Mann-Kendall trend test data are fit to four different periods: water years 1918 through 2012, 1981 through 2012, 1991 through 2012, and 2001 through 2012. Observed data are shown as triangles, LOWESS smooths as solid lines, and Mann-Kendall trends as dashed lines.

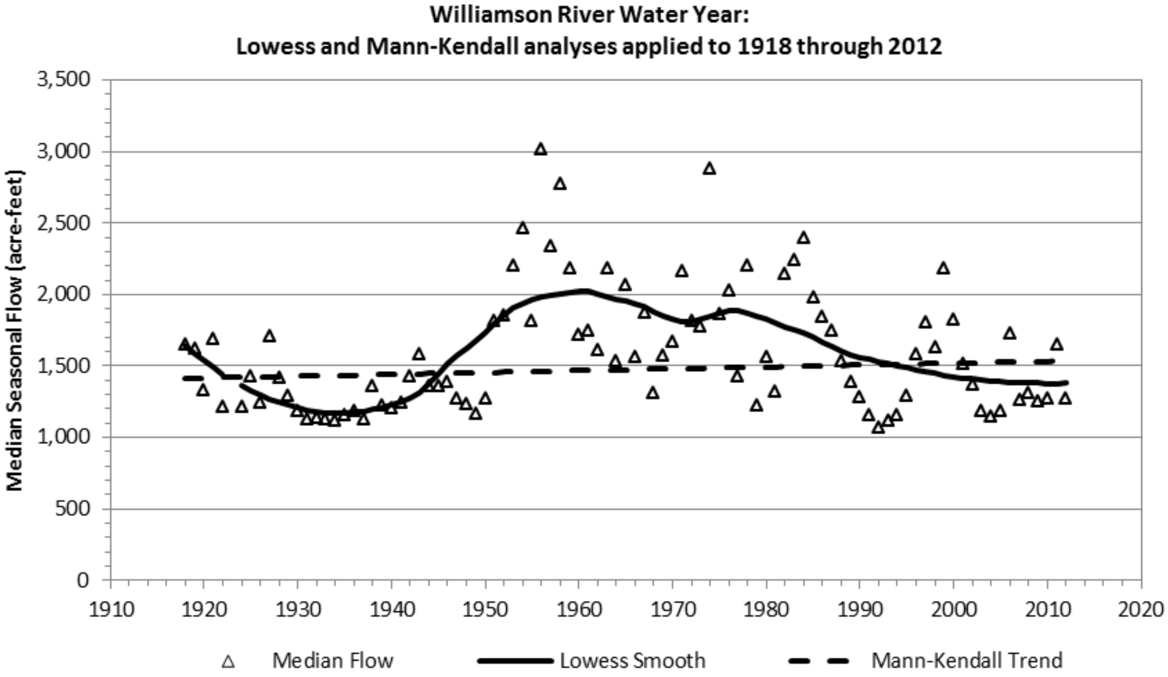


Figure 7.10 Williamson River trends, water years 1918 through 2012.

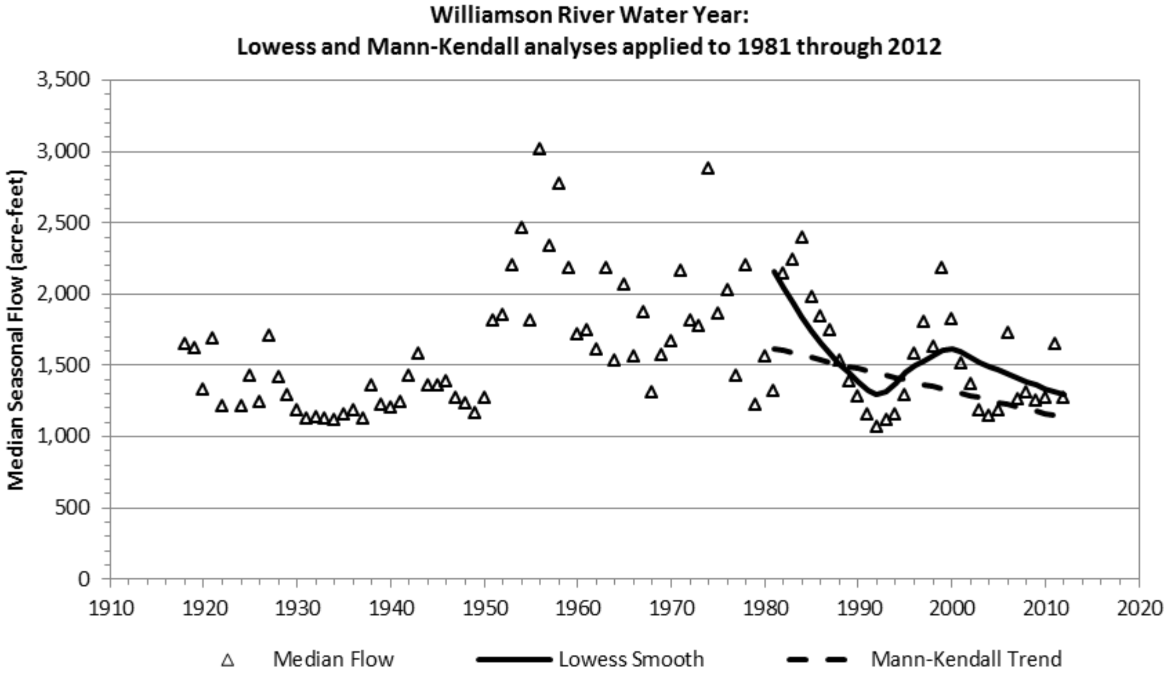


Figure 7.11 Williamson River trends, water years 1981 through 2012.

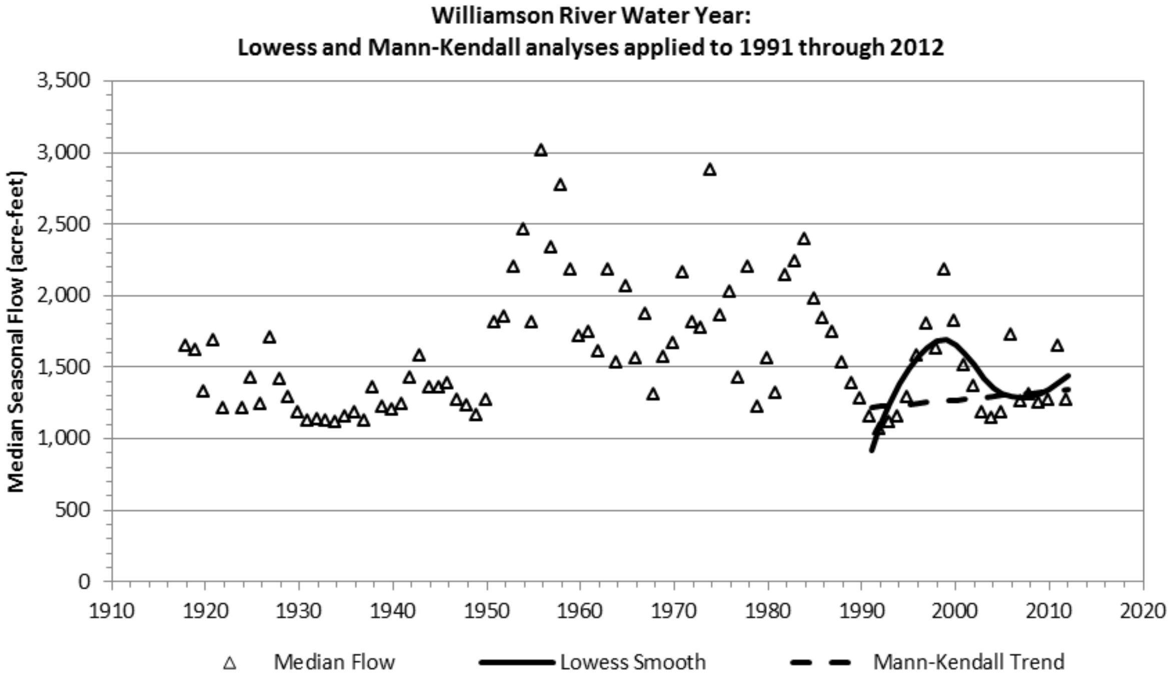


Figure 7.12 Williamson River trends, water years 1991 through 2012.

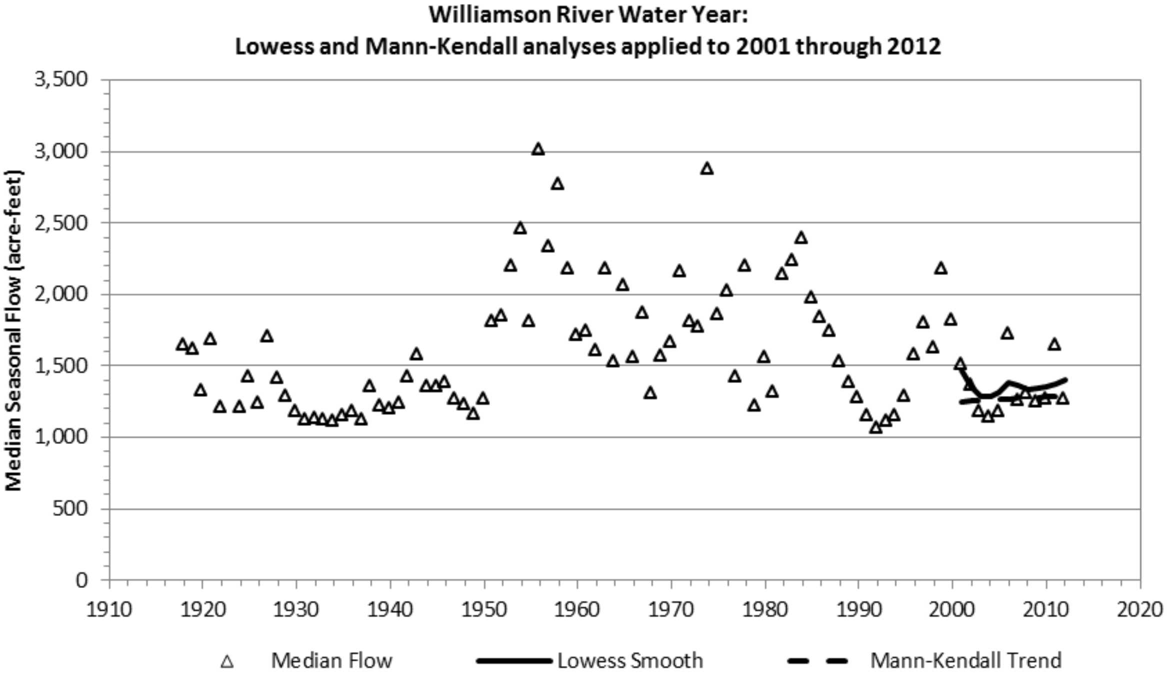


Figure 7.13 Williamson River trends, water years 2001 through 2012.

7.10.2.1.3 Upper Klamath Lake

Trends in UKL net inflow for the water year are shown in Figure 7.14 through Figure 7.16. Each graph shows identical observed median monthly flow data for water years 1981 through 2012. The LOWESS smooth and Mann-Kendall trend test data are fit to three different periods: water years 1981 through 2012, 1991 through 2012, and 2001 through 2012. Observed data are shown as triangles, LOWESS smooths as solid lines, and Mann-Kendall trends as dashed lines.

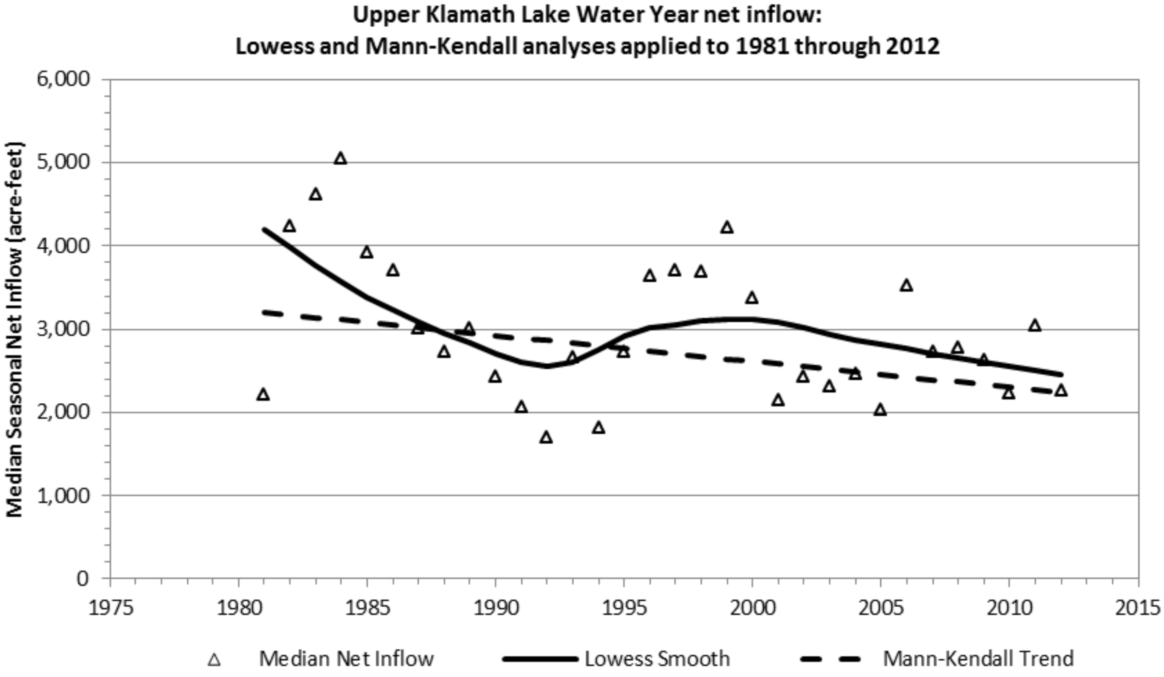


Figure 7.14 UKL trends, water years 1981 through 2012.

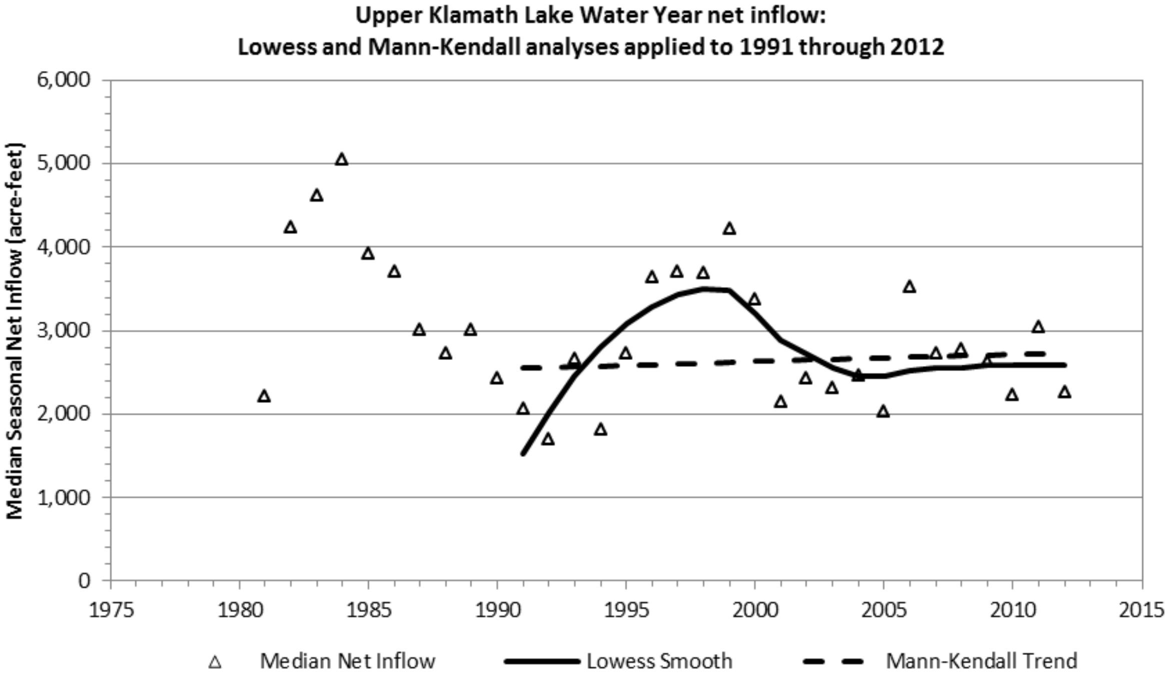


Figure 7.15 UKL trends, water years 1991 through 2012.

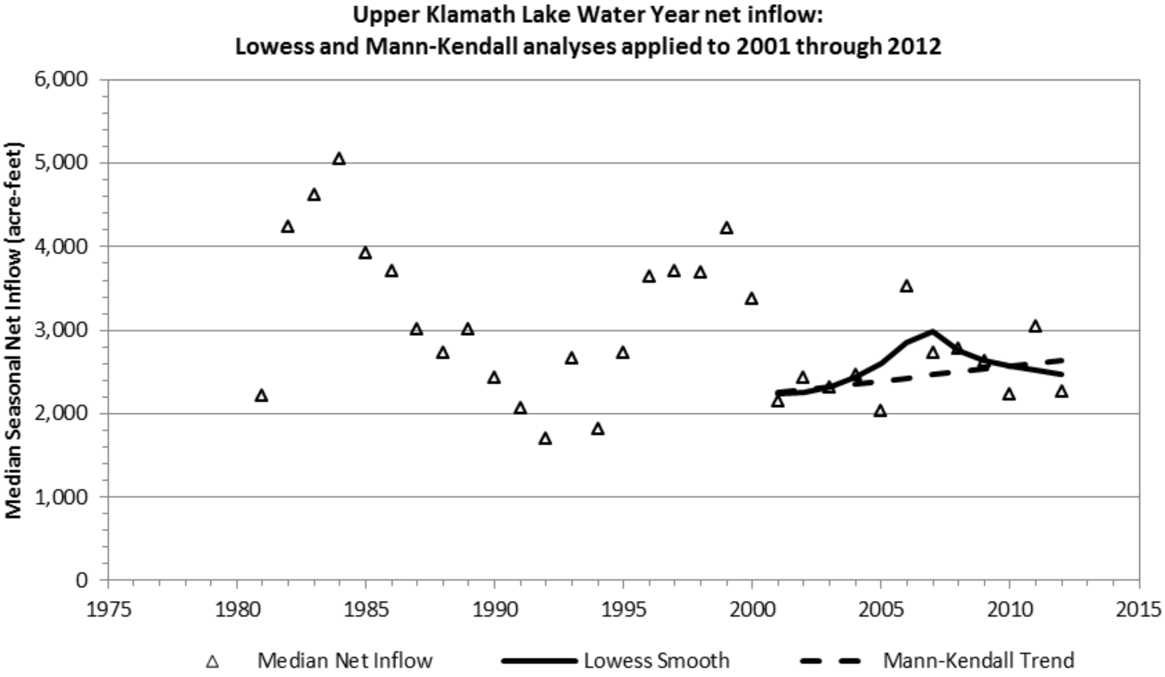


Figure 7.16 UKL trends, water years 2001 through 2012.

The results of trend analyses and review of overall inflow data suggest that high and low extremes of net inflow to UKL have declined during the period of record. Net inflow values both greater than and less than the median indicate the departure from the median is becoming less over time (Figure 7.17). In addition, high flow years are moving toward the median at a faster rate than low flow years. There is no inference of cause and effect in the evaluation of departure from median and extreme events will undoubtedly occur in the future. However, if this trend continues, the magnitude of extreme events will be less than occurred in the past.

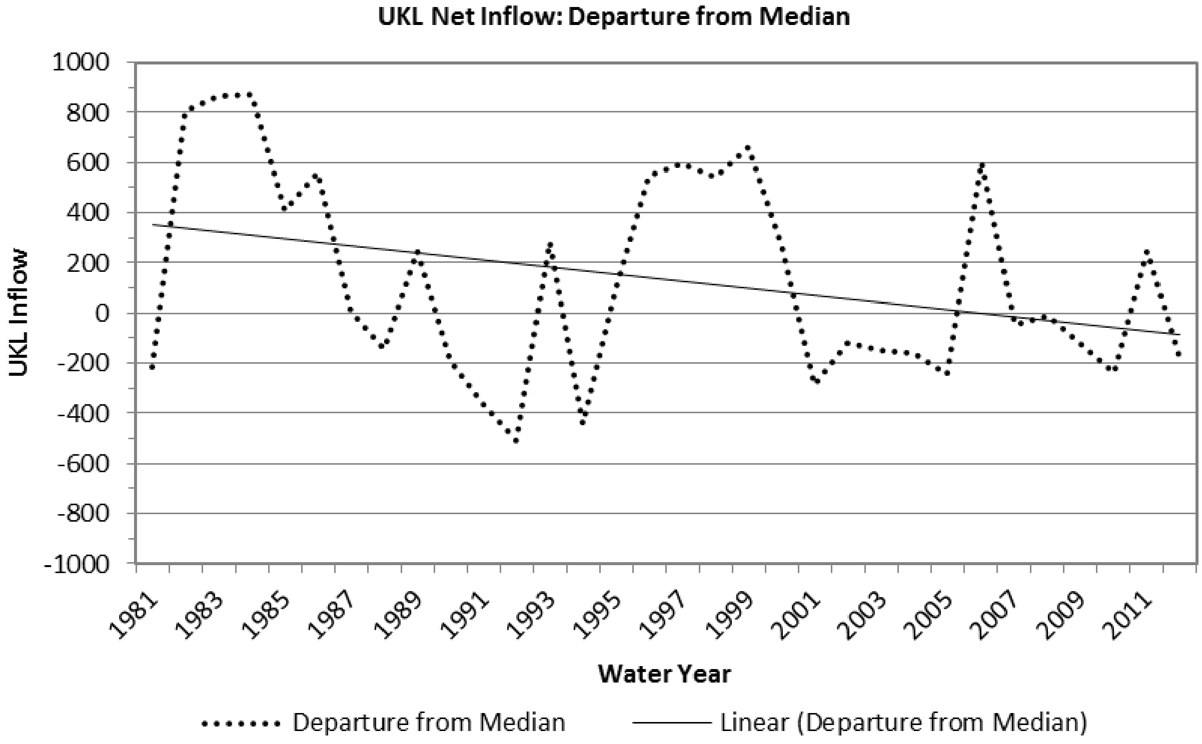


Figure 7.17 UKL: net inflow departure from median.

7.10.3 Disease, Parasites, Predation, and Competition

Disease, parasites, and predation are treated together here because they are related in terms of effects to suckers. For example, fish with external parasites could be infected by pathogens that enter the fish through a wound, and a fish weakened by disease or parasites could be more susceptible to predators because it behaves abnormally and may be less able to escape. In the USFWS 2008 BiOp on the Project (pages 69–72), we discussed aspects of sucker health based on information available at that time. New information continues to indicate that suckers in UKL are infected by parasites that cause sucker mortality (Markle et al. 2013).

7.10.3.1 Disease and Parasites

Neascus parasitism in age-0 suckers in has been monitored in UKL by Oregon State University scientists for two decades (Simon et al. 2012, Markle et al. 2013). SNSs are more frequently infected, and to a greater degree, than LRSs. Work by Markle and others (2013) indicates that SNS age-0 juvenile survival in UKL could be reduced by up to 38 percent because of *Neascus* infections. This mortality is likely mediated through fish-eating birds. Compared to *Neascus*, the parasitic anchor worm *Lernea cyprinacea* appears to have less of an impact on sucker growth and survival (Simon et al. 2012).

Similarly, rates of parasitism and other afflictions appear to be high in Lake Ewauna (Kyger and Wilkens 2011a). In 2010, 39 percent of suckers collected in Lake Ewauna were parasitized by *L. cyprinacea* and 17 percent by lampreys, a vertebrate parasite that preys on both adults and juveniles (Kyger and Wilkens 2011a). Nearly two-thirds of all suckers captured in 2010 exhibited some kind of physical affliction or abnormality, the most common being blindness, missing scales, cysts, and damaged or deformed fins and snout.

7.10.3.2 Bird Predation

Fish-eating birds have both direct and indirect effects on suckers. Birds directly affect suckers by preying on them, and indirectly by serving as the definitive host for trematode parasites that also infect suckers as intermediate hosts. The upper Klamath Basin has a diverse fish-eating bird fauna consisting of bald eagles (*Haliaeetus leucocephalus*), bitterns, herons, and egrets (Ardeidae), cormorants (*Phalacrocorax auritus*), ducks (e.g., mergansers [*Mergus* spp.] and goldeneyes [*Bucephala* spp.]), grebes (Podicipedidae), gulls (Laridae), belted kingfishers (*Megaceryle alcyon*), osprey (*Panidon haliaetus*), pelicans, large shorebirds such as yellowlegs (*Tringa* spp.), and terns (Sternidae). Smaller bird species like terns are capable of catching and consuming only age-0 suckers, while larger birds such as pelicans can capture and ingest even the largest adult suckers. The effects of bird predation depend in part on bird abundance, size of birds, their diet, and other factors.

Several sources of data document sucker predation by either pelicans or cormorants in the Klamath Basin. In 2009 and 2010, over 300 PIT tags were found at islands in Clear Lake, which are used for nesting and loafing by pelicans and cormorants (Roby and Collis 2011). The majority of tags (63 percent) were from the SNS; LRSs and KLSs represented 19 percent and 14 percent, respectively, of the tags. The tags represented suckers from UKL and its tributaries, Keno Reservoir, and Gerber Reservoir and its tributaries, but most tags were from Clear Lake. The tags were from suckers 3 to 27 in (7 to 69 cm) SL (average = 15 in [39 cm]) in size that were tagged from 1995 or later. In related research, approximately 20 percent of radio-tagged adult suckers from both species in Clear Lake were determined to have died as a result of bird predation (D. Hewitt, USGS, pers. comm., 2012). Additionally, over 100 PIT tags were recovered from islands in UKL used by nesting birds. Of these, the SNS, LRS, and the KLS represented 38 percent, 35 percent, and 15 percent of the tags, respectively. All of these PIT tags came from suckers originally tagged in UKL and the Williamson River.

Currently, we can only state with certainty that bird predation on the LRS and the SNS is occurring and it likely includes all life stages, including consumption of eggs by ducks at shoreline-spring spawning areas. Although it is difficult to quantify how bird predation affects sucker populations, it potentially could include a high percentage of mortality. Bird predation might have the most effect in Clear Lake because that is where most of the Klamath Basin's pelicans nest and because suckers, especially the SNS because of its long-distance migration, would be vulnerable during spawning migration through the relatively restricted migration corridor.

7.10.3.3 Competition and Predation by Nonnative Fishes

Historically, the LRS and the SNS co-occurred with at least 10 native fishes, which potentially interacted with the suckers as predators or competitors. Now, the Upper Klamath Basin fauna includes 20 nonnative fishes, many of which comprise a significant portion of the fish community (Scoppettone and Vinyard 1991). The nonnative fish species most likely to adversely affect the LRS and the SNS are the fathead minnow and yellow perch. These fishes are believed to prey on young suckers and compete with them for food or space (Markle and Dunsmoor 2007); although, specifics are unavailable. Given the very high abundances of fathead minnow known to occur in UKL, Lake Ewauna, and other areas, this interaction may be significant for early life stages of the LRS and the SNS.

7.10.3.4 Entrainment of LRS and SNS at the Outlet of UKL

Suckers of all life-stages are entrained at the Link River Dam and larval suckers are entrained at the A canal, both located at the outlet of UKL. The effects of entrainment on LRS and SNS have been described in previous consultations, the most recent being in 2008 (USFWS 2008, pages 72-76 and 127-135). Because that topic has been covered recently, we incorporate that information by reference. Entrainment causes the largest quantified loss of LRS and SNS and is estimated to involve millions of larvae and tens of thousands of juveniles (Gutermuth et al. 2000; USFWS 2008). Entrainment of planktonic sucker larvae in UKL is thought to be related to drift and wind-driven circulation patterns (USFWS 2008), but entrainment of juvenile suckers that are more bottom-oriented is likely more complex and is probably affected by multiple factors. Juvenile suckers that are entrained at the A Canal and Link River Dam could be dispersing, showing an avoidance response to poor habitat conditions, or a combination of these and other factors. Gutermuth et al. (2000a, b) found that entrainment of suckers at the Link River was higher during poor water quality events and thus leaving the lake could be an avoidance response because fish tend to avoid unfavorable conditions, such as low DO or high water temperatures (Sullivan et al. 2003).

Entrainment is more likely to occur now, compared to the pre-Project condition, because when Link River Dam was constructed, deep channels were cut through the reefs at the outlet of the lake (USBR 2001a). The reef closest to the lake was located at Putnam’s Point. The historical reef had a minimum elevation of approximately 4,137 ft (1,261 m), although most of the historical reef surface was at 4,140 ft (1,262 m), thus restricting downstream flows at this elevation (USBR, unpublished data). When the Link River Dam was built, it was determined that raising the lake more than a few feet would not be possible because of the risk it posed to existing dikes around the lake. Therefore, in order to maintain a sufficient water supply for agriculture, plans were put in place to lower the lake below its normal 2 ft (less than 1 m) range. In1921, to allow for lake levels to be drawn lower and to increase channel capacity, a cut about 8 ft (2.4 m) deep and 100 ft (30 m) wide was made through the upper reef near Putnam’s Point to an elevation of 4,131 ft (1,259 m; Boyle 1987). Downstream, a second reef located above the current dam had a low point at 4,137 ft (1,261 m), but most of the cross-sectional area was at an elevation of about 4,139 ft (1,262 m). Two cuts were made in this reef near the ends of the dam to increase flow and enable the lake to be lowered. The pre-Project water depths over both reefs mostly would have been only 1 to 2 ft (less than 1 m) in August and September when juveniles were present; now depths are 7 to 9 ft (less than 3 m) in the cuts. The shallow depths over much of the reefs likely reduced downstream movement of juvenile and adult suckers from UKL, but may have had no effect on larvae, which are weaker swimmers and surface oriented.

Hydraulic surveys made during July and September 1998 measured current velocities of up to 2 cfs (0.06 m^3/sec) in the area of the Link River upstream from the A Canal (Wahl and Vermeyen 1998; USFWS 2008, Figure 4-6). These flows are about twice the 1 ft/s (0.3 m/s) critical swimming speed (or approximately five body lengths per second) for age-0 juvenile suckers about 2.4 in (6 cm) in length (Delonay and Little 1997, Sechrist and Sutphin 2011), thus once small suckers get into the upper Link River above the dam, many, if not most, are likely swept downstream to the dam and then into the Keno Reservoir. We have no data regarding the current velocities prior to construction of the deep channels through the natural reef at the outlet of UKL. However, as noted above, the natural structure and elevation of this reef likely limited natural downstream migration of juvenile and adult suckers.

Based on studies at the outlet of UKL, most age-0 juvenile sucker losses from the lake that result from emigration and entrainment at the UKL outlet occur in July through October, with a peak in August and September (Gutermuth et al. 2000a, b; Foster and Bennetts 2006; Tyler 2007; Korson et al. 2011; Korson and Kyger 2012).

As a natural part of sucker life history in UKL, young suckers likely dispersed downstream from UKL to rear in Lower Klamath Lake and then returned to UKL as adults. That cycle was broken when access to Lower Klamath Lake was blocked by the construction of the railroad embankment in the early 1900s (Weddell 2000, Foster 2002). Further disruption of the dispersal patter from UKL to Lower Klamath occurred with the construction of the Link River Dam in the early 1920s. Now, most suckers that are entrained at the Link River Dam are considered lost to the breeding populations in UKL (USFWS 2007c, 2008); although, small numbers of adults annually return to UKL via the new fish ladder (Kyger and Wilkens 2010a).

Larval and juvenile survival in Keno Reservoir is low, probably due to the poor water quality and degradation, as described above, and loss of lake and wetland habitat due to agriculture conversion, railway construction, and near constant water level management (USFWS 2007c, 2008). Adult suckers in Keno Reservoir appear to avoid adverse water quality in the reservoir by moving into the Link River (Piaskowski 2003); they can re-enter UKL via the new fish ladder, but it is unknown to what extent smaller suckers are able to avoid adverse conditions in the Keno Reservoir so that they can survive and recruit into the adult population. Juvenile suckers are known to use marshes in Keno Reservoir; in 2010, Reclamation biologists captured 70 age-0 juvenile suckers in the largest remaining marsh, Tule Smoke (Phillips et al. 2011). However, because DO levels reached potentially lethal concentrations below 2 mg/L numerous times during the study, it is doubtful that this habitat consistently provides conditions necessary for sucker survival under current conditions.

7.10.4 Synergistic Effects of Water Quality, Parasites, Predation, Disease, and Entrainment on Juvenile Suckers in UKL

The available information discussed above suggest that a mid-to-late summer cascading series of events are likely responsible, in part, for the disappearance of age-0 juvenile suckers in UKL.

By late July, surviving larval suckers have metamorphosed into age-0 juveniles. Water quality has become highly dynamic, with wide daily swings in DO, pH, and total ammonia, which cause stress in the fish. Water temperatures peak at this time, reducing the capacity of the water to hold DO in solution. Higher temperatures also raise energy demands of fish, thus adding stress. Cyanotoxins can also be present at this time and, when concentrations are high, they damage the gut and liver, impacting the health of the fish, and leading to stress or mortality. Parasites, including protozoans like *Tricodina*, the copepod *Lernaea*, and the trematode *Neascus*, are also attacking the juveniles, adding additional stress and mortality. When fish are highly stressed and water temperatures high, protozoan parasites can multiply quickly, causing death in a few days. Additionally, in August and September, lake levels are declining and preferred habitats where food might be most abundant are disappearing, perhaps causing the juveniles suckers to relocate to areas where food might be less abundant. This movement also expends energy and further stresses the fish, and could increase their exposure to predators, especially fish-eating birds. Of those juveniles that survive, many end up at the south end of the lake and are entrained at the Link River Dam or in the forebay of the A Canal. Consequently, by early fall, very few juveniles survive in most years to enter the adult population 4 to 7 years later.

Table 7.9 Threats to the LRS and the SNS in UKL.

Threat	Nature of Threat	Life Stage Affected	Primary Effect	Mitigating Factor(s)	References
Entrainment at Link River	Mortality and loss from population	Mostly affects larvae and age-0 juveniles	Studies show this occurs annually, but extent varies among years	Will only affect larvae and juveniles at south end of UKL	Gutermuth et al. 2000a, b
Low Dissolved Oxygen Concentrations	Mortality or stress and reduced productivity	Juveniles and adults mostly due to timing	Good evidence that this led to die-offs in 1990s	Lethal conditions are variable in time and space and are unlikely to cover large areas of the lake; fish should be able to avoid affected areas to some degree	Perkins et al. 2000b
High Total Ammonia Concentrations	Mortality or stress and reduced productivity	Juveniles and adults mostly due to timing	New analyses show water quality exceeds LC_{50} values more than any other parameter	Lethal conditions are variable in time and space and are unlikely to cover large areas of the lake; fish should be	B. Martin, USGS, pers. comm., 2012

Threat	**Nature of Threat**	**Life Stage Affected**	**Primary Effect**	**Mitigating Factor(s)**	**References**
				able to avoid affected areas to some degree	
High pH	Mortality or stress and reduced productivity	All life stages	pH reaches >10	Unlikely to reach lethal levels and is temporary and localized, and fish can avoid affected areas	
High Water Temperatures	Mortality or stress and reduced productivity	Juveniles and adults mostly	Temperature reaches >28 ºC	Highly unlikely to reach lethal levels and is temporary and localized, and fish can avoid affected areas	
Algal Toxins	Mortality or stress and reduced productivity	Unknown but believed to be predominantly juveniles	Some aspects studied including: presence in UKL, route of entry, presence in gut, and tissue damage consistent with known effects of microcystin	Extent of effect not known and annual variability in time and space unknown	VanderKooi et al. 2010
Parasites	Stress and reduced productivity	All life stages likely affected but may have greater effect on age-0	Documented present for several species and effects of *Neascus* determined for SNS	Diversity of parasites and overall effects not well known	Simon and Markle 2004, Simon et al. 2011, Markle et al. 2013
Disease	Mortality, stress, and reduced productivity	All life stages likely affected but may have greater effect on age-0	Documented present	Appears to be mostly a concern when fish are highly stressed by other factors; difficult to duplicate in the lab	Foott et al. 2007
Predation	Mortality	All life stages but especially	Documented present	Effects not well	Dunsmoor and Markle

Threat	Nature of Threat	Life Stage Affected	Primary Effect	Mitigating Factor(s)	References
		age-0		documented especially at population level, but birds are known predators	2007, Roby and Collis 2011

7.10.5 Effects of Ecosystem Restoration and Recovery Actions for the LRS and the SNS

Since the early 1990s, the USFWS, Reclamation, NRCS, the State of Oregon, the Klamath Tribes, The Nature Conservancy, Klamath water users, other partners, and private landowners have been working to improve water quality and aquatic habitat conditions in the upper Klamath River Basin to support the recovery of the LRS and the SNS. Major habitat restoration efforts focusing on the endangered suckers have been completed or initiated. These include: (1) enhancement of thousands of acres of wetlands adjacent to UKL and in the watershed above the lake; (2) removal of Chiloquin Dam; (3) screening of the outlet of Clear Lake Dam; (4) construction of a new fish ladder at Link River Dam; and (5) screening of the A Canal.

7.10.5.1 Wetland Restoration in UKL

The re-establishment of approximately 2,600 ac (1,050 ha) of shallow water habitat at the Williamson River Delta, which is likely to be become emergent marsh (Elseroad 2004), is expected to provide good habitat for larval suckers, and will perhaps increase survivorship and reduce vagrancy and dispersal out of UKL where survival is currently minimal (Crandall et al. 2008; Hendrixson 2008; Markle et al. 2009; Erdman et al. 2010, 2011). Monitoring has shown that larval suckers are extensively using a variety of microhabitats in the newly reconnected wetlands; they have a greater gut-fullness, and in some years are larger, than larvae in the lake (Crandall et al. 2008; Erdman and Hendrixson 2010, 2011). Additionally, restoration at the Williamson River Delta altered the path water takes when it reaches the lake, which appears to have affected the distribution of larvae, making it less likely they will be transported out of the lake (Simon et al. 2012). On the potentially negative side: in some years habitat used by larval suckers becomes dewatered by mid-July; a large number of nonnative fish, including six species that could prey on larval suckers and three that could prey on juveniles, occur in the Williamson River Delta; catch rates of age-0 suckers decline to near zero by September; and water quality in areas with deep-water emergent and transitional wetlands is poor in late summer (TNC 2009, Burdick 2012, Burdick and Hewitt 2012). Additionally, wetland habitats in the Delta provide habitat for snails that could be one source of parasitic trematodes now infecting juvenile suckers.

Agency Lake Ranch and the Barnes properties (9,800 ac [4,000 ha]) along the northern and northwestern shores of Agency Lake were acquired by Reclamation and used as water storage areas, but are now managed as a part of the Upper Klamath NWR. Levees along these properties could be breached within the next 10 years; however, because of subsidence, much of the property will be too deep to maintain emergent wetland vegetation used by young suckers and will become open-water habitat. At maximum lake elevation only about 800 ac (320 ha) are likely to be suitable for the development of emergent vegetation, based on depth preferences of local emergent plant species distributed around UKL (Elseroad 2004).

It is not understood how fish will use these future wetland habitats on the Agency Lake Ranch and Barnes properties if they are opened to the lake, but larval and juvenile sucker monitoring in Agency Lake and Upper Klamath NWR (both adjacent to Agency Lake Ranch and Barnes) have detected low abundances of the LRS and the SNS (Buettner 2002, Terwilliger et al. 2004, Mulligan and Mulligan 2007).

7.10.5.2 Habitat Restoration and Enhancement in UKL Tributaries

The USFWS, NRCS, Klamath Tribes, and other State and local entities have focused watershed restoration and land and water conservation activities in the Sprague River watershed since 2002. There have been approximately 700 ac (280 ha) of wetland restored, 123 mi (198 km) of riparian fencing installed, 24 mi (39 km) of river channel realigned, stabilized or enhanced, 10 mi (16 km) of riparian planting, and four spring complexes reconnected and enhanced. Fish passage barrier removal and/or screening has occurred at 10 sites on the mainstem or tributary streams, including the removal of the Chiloquin Dam, which was a major barrier to fish passage upstream. Approximately 9,640 ac (3,900 ha) of floodplain habitat has been enrolled in permanent easements under the NRCS Wetland Reserve Program and Conservation Reserve Enhancement Program. NRCS has restored over 2,000 ac (800 ha) of wetland habitat and conserved several thousand acre-feet of on-farm water. More than 70 percent of the private lands in the Sprague River Valley are partnering with local, State, and Federal agencies on land conservation and natural resource actions.

Restoration projects on other tributaries to UKL have been completed by the USFWS. Additional restoration efforts have also been made by many other private, Federal, State, or local entities but we do not have data for these efforts. The acreages and other numbers listed below reflect the data available to us through USFWS' "Partners for Fish and Wildlife Program." The Wood River has had approximately 110 ac (45 ha) of wetlands restored or enhanced, 1 mi (1.6 km) of riparian fenced, 4 mi (6 km) of channel enhanced, and two diversions screened. Other tributaries to UKL (including Fourmile Creek, Crane Creek and Sevenmile Creek) have accomplished restoration of over 500 ac (200 ha) of wetlands (including several shoreline wetland projects on the southeastern portion of the lake), 15 mi (24 km) of fencing, 9 mi (15 km) of channel restoration or enhancement, two springs enhanced, nine fish passage barriers removed or diversions screened, and over 4 mi (6 km) of riparian plantings. NRCS has 8,894 ac (33,599 ha) of floodplain habitat currently enrolled in easements throughout this area.

It is difficult to quantify the effects these restoration activities have on the populations of the LRS and SNS, because more time is required in some cases and because the effects of ecosystem restoration are often diffuse in nature; nevertheless, recent data provide some insight. Kann and Walker (2012) observed a statistically significant decline in phosphorus inputs into UKL from 1992-2010, which is anticipated will affect blue-green algae dynamics in ways that are beneficial to suckers. Likewise, sucker larvae utilizing the restored Williamson River delta (Erdman et al.

2011) and increased adult spawning migrations upstream of the former Chiloquin Dam site (Martin et al. 2013) have been documented.

7.10.5.2.1 Chiloquin Dam Removal

In 2008, Reclamation and the Bureau of Indian Affairs removed Chiloquin Dam located near the confluence of the Sprague and Williamson Rivers. This action was expected to increase sucker access to habitats in the Sprague River watershed as far upstream as Beatty where listed sucker spawning and rearing have been documented (Ellsworth et al. 2007, Tyler et al. 2007). However, monitoring results suggest that the upstream extent of spawning by the LRS and the SNS has not substantially changed since the dam was removed, and most of their spawning continues to occur below the former dam site (Ellsworth and Martin 2012).

7.10.5.2.2 A Canal Fish Screen and Fish Bypass Facility

Reclamation completed construction of a state-of-the-art fish screen at the entrance to the A Canal in UKL in 2003 to reduce the high rates of fish entrainment known to occur at this diversion site. LRS and SNS larvae and juvenile life stages were particularly vulnerable to entrainment at A Canal before the screen was installed (Gutermuth et al. 2000a). The screen is designed to protect most age-0 juveniles (greater than 1.2 in (30 mm) total length) and subadult suckers that pass through the trash rack openings. Although the screen mesh openings are large enough to allow larval suckers to pass, the hydraulic conditions that create positive sweeping flows across the screen surface guide approximately 50 percent of the larvae into the bypass and back into UKL (Bennetts et al. 2004). However, because the A Canal bypass discharges back into UKL just upstream of Link River Dam, it is likely that most of the bypassed larval suckers continue to disperse downstream out of UKL. The fate of juvenile and subadult suckers bypassed at A Canal is also unknown, but more are likely to return to UKL, especially adults.

7.10.5.2.3 Link River Fish Ladder

Reclamation constructed a new vertical slot fish ladder at Link River Dam in December 2004. The new ladder was specifically designed to allow suckers, which are not strong jumpers, to easily swim through the slots and migrate above Link River Dam (Reclamation 2002b). Limited monitoring of suckers has been conducted using radio and remote PIT tag receivers (Reclamation 2007, Korson et al. 2008, Kyger and Wilkens 2011a). Between 2008 and 2011, a total of 69 PIT-tagged suckers were detected passing antennas positioned in the fish ladder. The numbers were about equally divided between the LRS and the SNS, although SNSs have dominated catches in Lake Ewauna. Assuming there are 2,000 adult suckers in the Keno Reservoir and that the tagged fish are representative of upstream movement by this population, fewer than 1 percent of the adult LRS and SNS populations in Keno Reservoir move upstream each year (Kyger and Wilkens 2010a). The reason for this is unknown.

7.10.5.3 Scientific Take Under Section 11 of the Endangered Species Act

Section 11 of the Act authorizes scientific permits for research or to enhance the survival and recovery of listed species. The USFWS issues research permits under conditions that are protective of sucker populations. To date, we have no information that supports a finding that these research activities are detrimental to the affected sucker populations. Additionally, the

Oregon Department of Fish and Wildlife requires scientific take permits that are reviewed to ensure there is minimal impact to native fish populations.

7.10.6 Conclusions Regarding the Ability of the Action Area to Support LRS and SNS Conservation

The recovery plan for the LRS and the SNS establishes a strategy that is intended to produce healthy, self-sustaining populations of the LRS and the SNS within the action area by reducing sucker mortality; restoring habitat, including sucker spawning, larval, and juvenile habitats; and increasing connectivity between sucker spawning and rearing habitats (USFWS 2013). Recovery also involves ameliorating the adverse effects of degraded water quality, disease, and nonnative fish on LRS and SNS populations. The recovery goal is to produce naturally self-sustaining populations that possess healthy long-term demographic traits and trends (USFWS 2013).

UKL is especially critical to the conservation of the LRS and the SNS because it provides the most habitat and has the greatest variety of spawning sites. Currently, the largest population of the LRS is found in UKL and its tributaries. It is possible that UKL supported the largest SNS population, but its abundance there has decreased substantially from a decade ago (Hewitt et al. 2012). Even though the LRS and the SNS are dependent on UKL during nearly every life stage, conditions in the lake are seasonally adverse due to poor water quality, algal toxins, and other factors. Suckers stressed by poor water quality are more vulnerable to disease, predators, and entrainment. There is also a variety of parasites in the lake that reduce sucker survival. Habitat conditions also have been degraded by loss of wetlands. Substantial entrainment of larval and juvenile suckers occurs at the outlet of UKL. The nearly universal disappearance of juvenile suckers from UKL beginning in August and extending into October (Simon et al. 2011), likely in response to the synergistic effects of the above factors, has precluded adequate recruitment into the adult populations of the LRS and the SNS in UKL in over a decade; neither the LRS or the SNS populations in UKL exhibit normal population demographic patterns and are not self-sustaining. This lack of recruitment is increasing the risk for a collapse and extirpation of the LRS and the SNS from UKL as the older adult populations continue to age and die.

Keno Reservoir and the downstream hydroelectric reservoirs are highly altered systems that currently support small sucker populations, mostly of the SNS. All of these areas provide recovery benefits by adding redundancy, but currently they do not support self-sustaining populations because of habitat limitations. Because Keno Reservoir is downstream of UKL, and large numbers of suckers disperse there from upstream, it has the potential to provide rearing habitat for suckers that ultimately could migrate back to UKL. Nevertheless, habitat and water quality conditions in the Keno Reservoir are seasonally adverse, and are unlikely to change substantially over the next decade.

Climate change is having a small but measureable effect over the entire Klamath River Basin. Air and water temperatures are increasing, and inflows to UKL are diminishing, at least during the summer to early winter period. The effects of climate change on air and water temperatures and on the magnitude, duration, and timing of inflows to UKL are expected to get more severe in the future (Flint and Flint 2011, Markstrom et al. 2011).

Based on the best available information on the range-wide status of the LRS and the SNS and the factors influencing that status, the USFWS concludes that the LRS and the SNS are critically endangered due to the lack of population resiliency and redundancy, and are at a high risk of extinction unless and until sufficient amounts of recruitment occur into the adult breeding populations of both species to more normalize population age structure, demographic patterns, and relative distribution within the Klamath River Basin. Although considerable efforts have been made to reduce the threats to the LRS and the SNS, all of the threats discussed above are extremely difficult to address in the short-term, or, like climate change, cannot be reduced, and consequently are unlikely to be substantially ameliorated in the near future.

7.11 Habitat Conditions and Status of the Species within the Lost River Recovery Unit

This section will address habitat conditions and factors affecting conditions for LRS and SNS within the east side of the action area, which includes the Lost River Basin. The east side of the Project consists of Langell Valley and Horsefly Irrigation Districts. Reclamation operates Clear Lake and Gerber Reservoirs to provide irrigation water to Langell Valley and Horsefly Irrigation District customers and other Project water users (Reclamation 2012). Although the proposed action include Tule Lake as part of the west side, USFWS revised recovery plan includes Tule Lake in the Lost River Recovery Unit; therefore, for the purposes of this analysis, we will discuss baseline conditions for Tule Lake in this section.

SNS are found throughout the Lost River sub-basin, including Gerber Reservoir, the Lost River, Tule Lake, and Clear Lake, where the largest range-wide population might occur. LRS are present in Clear Lake and Tule Lake, but not in large numbers, are in very low numbers in the Lost River, and are not present in Gerber Reservoir. The only habitats occupied by LRS and SNS that are not included in the east side of the action area are tributaries of the Project reservoirs, e.g., Willow Creek above Clear Lake, and Barnes Valley and Ben Hall Creeks above Gerber Reservoir.

The east side of the action area overlaps the Lost River Recovery Unit for the suckers, with the exception of Tule Lake, but discussed here for purposes of the analysis. As was discussed in section 7.4.2, the Lost River Recovery Unit is also subdivided into four management units: Clear Lake, Tule Lake, Gerber Reservoir (SNS only), and the Lost River proper.

The recently revised recovery plan for the LRS and SNS states that their most immediate threats are the absence of resiliency and redundancy (USFWS 2013). In this context, resiliency is the ability of a population or species to rebound after stressful environmental conditions, such as adverse water quality, increased predation, disease, drought, or climate change. Redundancy, in this context, involves multiple populations spread over the landscape to reduce the likelihood of simultaneous extirpation from catastrophic events, such as adverse water quality, drought, or disease. Therefore, a focus of this discussion is to determine how the baseline conditions in the action area affect the ability of multiple LRS and SNS populations to respond and persist in a changing and adverse environment.

7.11.1 Clear Lake

The major known threats to LRS and SNS in Clear Lake are prolonged drought and bird predation. Entrainment might also be a threat, but has not been studied. Water quality and disease are not normally issues at Clear Lake but, during droughts and periods with low lake levels, parasitism and food abundance might be factors adversely affecting suckers. The effects of drought on suckers in Clear Lake were covered in previous consultations, the most recent being the USFWS 2008 BO and Reclamation's 2012 BA, which has a lengthy description of Clear Lake hydrology and the effects of drought. Because there are several recent hydrologic baseline analyses for Clear Lake, we will focus only on the main points here (USFWS 2002, 2008, Sutton and Ferrari 2010).

Periodic low inflows into Clear Lake, combined with irrigation diversions, high seepage, and evaporative losses, can result in low water levels during multiyear droughts, as experienced in 2009–2010. During drought conditions the lake level continues to decline as a result of evaporation and seepage, even without irrigation releases. This is because annual April through October evaporative and seepage losses from Clear Lake average approximately 44,000 acre-feet while seasonal irrigation releases average about 38,000 acre-feet (Reclamation, unpublished data).

Low lake levels can adversely affect LRS and SNS by limiting access to Willow Creek, the only known spawning area for the suckers in Clear Lake (USFWS 2002, 2008). A minimum lake level of about 4,524.00 ft (1,378.92 m) is believed necessary to provide spawning access to the creek (Reclamation 2003, USFWS 2008). Impaired access to Willow Creek can prohibit or reduce sucker reproduction at Clear Lake in any given year. A survey of hydrologic connectivity of lower Willow Creek, the channel between the east lobe of Clear Lake and Clear Lake Dam, and the channel between the east and west lobes of Clear Lake, indicated that a hydrologic control point at an elevation of 4,521.70 ft (1,378.21 m) exists between the east lobe and the mouth of Willow Creek (Sutton and Ferrari 2010). A functional disconnect occurs between surface waters of the east lobe and the dam, including the mouth to Willow Creek, when the east lobe of Clear Lake drops below an elevation of about 4,522.00 ft (1,378.31 m; Sutton and Ferrari 2010). At a lake elevation of 4,525.00 ft (1,379.22 m), this hydrologic control is inundated with approximately 3 ft (less than 1 m) of water, which available information indicates is sufficient for passage by adult suckers, but still so shallow that it could expose them to pelican predation.

Detections of passive integrated transponder (PIT)-tagged adult suckers in Willow Creek in relation to lake elevations measured at the dam indicate that LRS and SNS movement into Willow Creek from 2006 through 2011 appears to be predominantly a function of Willow Creek discharge. Adult suckers appear to enter the creek on a cue of creek discharge, but lake elevation may also play an important role in some years (Barry et al. 2009; USBR 2012). In years with higher lake elevation relatively large numbers of tagged suckers were detected in spawning runs. However, in years when there are no substantial inflows, spawning migrations are relatively small in numbers regardless of lake elevations. The number (n = 121) of PIT-tagged adult suckers detected in Willow Creek in 2007 was 7 and 9.5 times lower than in 2006 and 2008, respectively (Barry et al. 2009). Water levels in Clear Lake on February 1, 2007 were relatively high (4528.21 feet [1380.20 m]), but the flows through April 29 were very low, increasing the overall water level by only 5 inches (12.5 cm), even though no withdrawals were occurring. In contrast, water levels began 1.5 ft (0.5 m) lower in 2006 than in 2007, and water levels were lower in 2008 than 2007 through the entire spawning season, but both of these years still had much higher numbers during the spawning runs. The difference is that flows were much higher during 2006 and 2008 than 2007, increasing the overall Clear Lake water levels during the spawning season by 5 ft (1.5 m) and 3.5 ft (1.1 m), respectively.

The patterns observed during 2006 and 2008 suggest that even if Clear Lake levels are low early in the season but inflows are high, water levels can rise quickly by the time suckers need to enter the creek for spawning. Similar patterns occurred in 2011 as well (USBR 2012). Thus, it appears that low lake levels per se are not a determining factor for spawning in some years. Nevertheless, Clear Lake water elevations may be important during years with flows that could be sufficient to encourage runs but insufficient to substantially increase lake levels. More observation and monitoring must be completed to more fully understand this relationship.

An evaluation of the surface elevations for Clear Lake during the February through May spawning period during the POR, shows surface elevations were above 4,525.00 ft (1,379.22 m) 80 percent of the time (Table 7.10).

Table 7.10 Clear Lake elevation exceedances February through May. POR =1903-2012. (Reclamation 2012 BA, Table 6-3).

Exceedance (Percent)	**February (Feet)**	**March (Feet)**	**April (Feet)**	**May (Feet)**
95	4,521.47 (1,378.14 m)	4,522.75 (1,378.53 m)	4,523.03 (1,378.62 m)	4,522.57 (1,378.48 m)
90	4,523.04 (1,378.62 m)	4,524.32 (1,379.01 m)	4,525.05 (1,379.24 m)	4,524.76 (1,379.15 m)
85	4,524.33 (1379.02 m)	4,525.90 (1,379.49 m)	4,526.04 (1,379.54 m)	4,525.69 (1,379.43 m)
80	4,525.37 (1,379.33 m)	4,526.58 (1,379.70 m)	4,527.33 (1379.93 m)	4,526.84 (1,379.78 m)
75	4,526.00 (1379.53 m)	4,527.15 (1,379.88 m)	4,528.51 (1,380.29 m)	4,527.73 (1,380.05 m)
70	4,526.71 (1379.74 m)	4,527.70 (1,380.04 m)	4,528.85 (1,380.39 m)	4,528.75 (1,380.36 m)
65	4,527.37 (1,379.94 m)	4,528.69 (1,380.35 m)	4,529.60 (1,380.62 m)	4,529.34 (1,380.54 m)
60	4,528.30 (1,380.23 m)	4,529.79 (1,380.68 m)	4,530.94 (1,381.03 m)	4,530.55 (1,380.91 m)
55	4,529.63 (1,380.63	4,530.60	4,531.52	4,531.12 (1,381.09

	m)	(1,380.93 m)	(1,381.21 m)	m)
50	4,530.41 (1,380.87 m)	4,531.28 (1,381.13 m)	4,532.28 (1,381.44 m)	4,532.05 (1,381.37 m)

During droughts, suckers concentrated in shallow water are likely to experience increased rates of disease, parasitism, and bird predation (USFWS 2008). It is also reasonable to assume that the resulting high densities of fish could deplete the food supply, causing additional stress, loss of productivity, and possible mortality. In 1992, when Clear Lake elevation reached a minimum of 4,519.40 ft (1,377.51 m) in October, suckers showed signs of stress by the following spring, including low body weight, poor gonadal development, reduced juvenile growth rates, and high incidence of external parasites and lamprey wounds (Reclamation 1994). At higher lake levels in 1993 to 1995, overall fish body conditions improved, with increased body weight and fewer external parasites and lamprey wounds observed (Scoppettone et al. 1995).

Bird predation on LRS and SNS in Clear Lake appears substantial. For example, in 2010 and 2011, there was evidence that 20 percent of suckers fitted with radio transmitters were consumed by either pelicans or cormorants. Because this number was based only on transmitters recovered from nesting colonies, and transmitters might have been deposited elsewhere, this value is considered the minimal predation rate (Hewitt, USGS, pers. comm. 2012) experienced by suckers during this time period.

Bird predation is likely to be more intense during periods of low water levels because the shallow depths would enable pelicans to reach suckers in depths of less than 3 ft (less than 1 m). Additionally, suckers are vulnerable to bird predation during spawning migrations, especially if flows in Willow Creek decline sharply during migration, stranding suckers and making them more visible. Although SNS might be most vulnerable to bird predation because of their longer migration in Willow Creek, the larger size of LRS could make them more vulnerable throughout the year because they are more easily detected. Additional studies are needed to determine the full effect of bird predation on these populations.

Prolonged drought coupled with irrigation diversions, seepage, and evaporation results in a substantial reduction in lake surface area and depth, and likely poses a threat to LRS and SNS. Missing year-classes is likely evidence of these threats. Other potential threats at Clear Lake include entrainment and stranding below the dam once irrigation diversions are terminated, but no studies have been done to document these, so their effects are unknown.

7.11.2 Gerber Reservoir

The only listed suckers known to be present in Gerber Reservoir and its tributaries are SNS. The primary known threat to SNS populations in Gerber Reservoir is an extended multiple-year drought that would result in low lake levels that could initiate a fish die-off during the late summer and fall, or during prolonged ice cover conditions in the winter (USFWS 2008); however, these conditions have not occurred to date. During 1986 through 2004, irrigation releases measured through Gerber Dam were 31,000 acre-feet from April through October, with evaporation and seepage estimated at 17,000 acre-feet for the same period (Reclamation, unpublished data).

Adult spawning principally occurs in Barnes Valley and Ben Hall Creeks. Access to these creeks is believed to require a minimum surface elevation of about 4,805.00 ft (1,464.56 m) during the February through May spawning period (USFWS 2008). Based on the POR (Table 7.11), lake levels are likely to provide access into spawning tributaries in all but the driest years. Additionally, during very dry years both Barnes Valley and Ben Hall Creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation 2001a). Thus, low lake levels during the POR have not likely impeded spawning.

Table 7.11 Gerber Reservoir elevation exceedances, February through May. POR = 1925-2012 (Reclamation 2012, Table 6-4).

Exceedance (Percent)	February (Feet)	March (Feet)	April (Feet)	May (Feet)
95	4,804.88 (1,464.53 m)	4,809.12 (1,465.82 m)	4,810.01 (1,466.09 m)	4,809.55 (1,465.95 m)
90	4,807.68 (1,465.38 m)	4,813.37 (1,467.12 m)	4,815.94 (1,467.90 m)	4,816.35 (1,468.02 m)
85	4,810.75 (1,466.32 m)	4,815.16 (1,467.66 m)	4,818.85 (1,468.79 m)	4,817.76 (1,468.45 m)
80	4,812.72 (1,466.92 m)	4,817.63 (1,468.41 m)	4,820.27 (1,469.22 m)	4,819.15 (1,468.88 m)
75	4,814.48 (1,467.45 m)	4,818.76 (1,468.76 m)	4,821.41 (1,469.57 m)	4,820.27 (1,469.22 m)
70	4,815.82 (1,467.86 m)	4,820.14 (1,469.18 m)	4,822.45 (1,469.88 m)	4,820.94 (1,469.42 m)
65	4,817.11 (1,468.26 m)	4,821.56 (1,469.61 m)	4,824.41 (1,470.48 m)	4,822.58 (1,469.92 m)
60	4,817.78 (14,68.46 m)	4,822.64 (1,469.94 m)	4,825.28 (1,470.75 m)	4,823.55 (1,470.22 m)
55	4,818.15 (1,468.57 m)	4,824.02 (1,470.36 m)	4,826.90 (1,471.24 m)	4,825.17 (1,470.71 m)
50	4,820.02 (1,469.14 m)	4,824.89 (1,470.63 m)	4,827.70 (1,471.48 m)	4,826.56 (1,471.14 m)

Summer surface elevations at Gerber Reservoir less than 4,800.00 ft (1,463.04 m) significantly reduce juvenile and adult sucker habitat, and are likely to result in increased competition for food, higher predation, and reduced fitness due to parasites and disease (Reclamation 2002, USFWS 2008). Surface elevations below 4,800.00 ft (1,463.04 m) are infrequent at Gerber Reservoir (USBR 2012); in the POR elevations were below 4,800.00 ft (1,463.04 m) in only 5 years (Reclamation 2012). Only in 1991 and 1992 were surface elevations below 4,800.0 feet for longer than 1 or 2 months (USBR 2012). At 4,800.00 ft (1,463.04 m), the surface area of Gerber Reservoir decreases to about 750 ac (300 ha). At a surface elevation of 4,815.00 ft (1,467.61 m), there are about 2,000 surface ac (800 ha) with adequate depth to support adult suckers.

Table 7.12 September 30th Gerber Reservoir elevation exceedances 1925-2012 (Reclamation 2012, Table 6-4).

Exceedance (Percent)	Elevation (Ft)
95	4,798.19 (1,462.49 m)
90	4,802.46 (1,463.79 m)
85	4,804.22 (1,464.33 m)
80	4,806.05 (1,464.88 m)
75	4,807.35 (1,465.28 m)
70	4,809.43 (1,465.91 m)
65	4,811.65 (1,466.59 m)
60	4,812.74 (1,466.92 m)
55	4,814.25 (1,467.38 m)
50	4,815.70 (1,467.83 m)

Gerber Reservoir water quality is seasonally degraded, especially near the bottom where DO concentrations reach 2 mg/L during the summer (Reclamation 2009). This could lead to prolonged low oxygen conditions if ice covered the surface for several months. Algal bloom advisories were issued for AFA by the Oregon Health Authority between August and January in both 2010 and 2011. In October 1992, the water surface elevation of Gerber Reservoir reached a minimum of 4,796.40 ft (1,461.94 m) before the onset of a prolonged and cold winter; however, no winter fish die-offs were observed (USFWS 2008). SNS during the summer of 1992 and following the winter of 1992 to 1993 showed signs of stress, including low body weight, poor gonadal development, and reduced juvenile growth rates, but no mass mortality was observed (USFWS 2008).

The outlet of Gerber Reservoir is unscreened and suckers are entrained. In 2003, a total of 76 juvenile SNS were captured in a screw trap positioned in Miller Creek below the dam (Hamilton et al. 2003). Very few data exist concerning the subsequent disposition of individuals after passing through the facility, but 1 to 3 suckers greater than 6 in (15 cm) SL and 144 suckers smaller than that were captured in 1999 near the confluence of Miller Creek and the Lost River (Shively et al. 2000).

Gerber Reservoir has large populations of nonnative fishes, including several that are potential predators of suckers, such as white crappie (*Pomoxis annularis*), yellow perch (*Perca flavescens*), and fathead minnows (*Pimephales promelas*) which can both prey on larval suckers and compete with juveniles. In fact, the majority of the Gerber Reservoir fish fauna is comprised of these three exotic fishes (Reclamation 2009).

7.11.3 Lost River

The Lost River currently supports small numbers of SNS and very few LRS (Koch and Contreras 1973, Buettner and Scoppettone 1991, Shively et al. 2000, Reclamation 2009). Of 105 adults captured by Shively et al. (2000) in 1999, 87 were identified as SNS and only one was identified as LRS; the remaining were identified as Klamath largescale suckers or intermediate morphology. The majority of both adults and juveniles are caught above Harpold Dam and, to a lesser extent, from Wilson Reservoir (i.e., impoundment behind the Lost River Diversion Dam; Shively et al. 2000). The riverine reach from Malone Reservoir upstream to Clear Lake Dam is not expected to support large numbers of suckers due to its high gradient and lack of deep pool habitat (USFWS 2008).

The Lost River has been highly altered to meet the needs of agriculture and reduce the threat of flooding, and therefore habitat is fragmented and disconnected by dams lacking fish passage (Reclamation 2009). Its hydrology is affected by a complex system of canals, pumps, and dams used to manage irrigation delivery and return drainage. Much of the water flowing through the lower Lost River channel comes from UKL via the A Canal, and is therefore high in nutrients. Because this water is reused many times by different users, nutrient concentrations are increased (ODEQ 2010). Water flowing in the Lost River eventually empties into the Tule Lake NWR as return flow from irrigation (no water is released through the Anderson-Rose Dam) and can be pumped to the Lower Klamath NWR before flowing to the Klamath River via the Klamath Straits Drain (Reclamation 2009).

Adequate flow and habitat conditions in the Lost River are likely to occur during the spring and summer, with higher river flows augmented by releases from Clear Lake and Gerber Reservoirs (USFWS 2008). Irrigation releases typically start in April and augment groundwater and low-elevation runoff in this river reach. Flows in the Upper Lost River are very low during the fall and winter because flows from Clear Lake and Gerber Reservoirs are substantially reduced. However, winter flows do increase downstream from tributary and spring accretions (USFWS 2008).

Owing to extensive alterations of the Lost River watershed, inputs from UKL, and agricultural drainage, water quality is seasonally poor and the river is listed by the State of Oregon for exceedances in temperature, DO, pH, algal biomass, and ammonia toxicity (ODEQ 2010). A high biomass of aquatic plants and AFA contributes to poor conditions in the river (Reclamation 2009, ODEQ 2010). Most water quality parameters show increasing degradation in the downstream direction. Seasonally low DO concentrations occur throughout the Lost River, and can be especially low in reservoirs where concentrations less than 2 mg/L lasting from a day to several weeks have been reported from Anderson-Rose, Harpold, and Wilson Reservoirs, with DO concentrations near 0 mg/L observed in some reservoirs (Reclamation 2009). Ammonia concentrations are also likely stressful or lethal to fish. Water temperatures in Wilson Reservoir are stressful, reaching 86º F (30º C; Reclamation 2009). As a result of the sometimes extremely poor water quality in the Lost River, fish die-offs are frequent in summer; one of the largest occurred in July 2003, when 146 adult suckers were found dead (Reclamation 2009).

In addition to the adverse habitat conditions in the Lost River, there are over 130 diversions (Reclamation 2001); few, if any, of these are fitted with fish screens that meet State and Federal criteria. Additionally, dams block passage of suckers to areas of better water quality and spawning habitats.

7.11.4 Tule Lake

Tule Lake consists of two sumps (Sumps 1A and 1B) managed to meet flood control and wildlife needs, including the needs of endangered suckers in the case of Sump 1A. Reclamation, through a contract with Tulelake Irrigation District, manages deliveries from the sumps and pumping from D-Plant to aid Tule Lake NWR in maintaining the elevations necessary in the sumps to meet wildlife needs and requirements (Reclamation 2007). Water levels in Tule Lake sump 1A have been managed according to criteria set in previous biological opinions (USFWS 2002, 2008), with elevations in Sump 1A maintained at a minimum of 4,034.00 ft (1,229.56 m) from October 1 through March 31, and a minimum of 4,034.60 ft (1,229.45 m) from April 1 through September 30 (USFWS 1992).

Both LRS and SNS reside in Sump 1A of Tule Lake, but the majority is LRS. Two hundred thirty LRS and 202 SNS were captured and tagged during surveys from 2006 to 2008. Eighteen tagged suckers were put into Sump 1B in May and November 2011, but these quickly returned to Sump 1A when access was provided in 2012. It is not known why suckers do not inhabit sump 1B even though they have access to it from sump 1A. The 2011 effort indicates that although they survived in sump 1B, they moved back to sump 1A as soon as they had access indicating a preference for this sump. The current numbers of suckers in Sump 1A are relatively small and have been roughly estimated to number less than 1,000 adults of each species (USFWS 2008). Surveys were also unsuccessful in finding juveniles but it is not known if this is a result of sampling methods or a lack of presence. More studies are needed to determine the origin of these fish and their current abundance (Hodge and Buettner 2007, 2008, 2009).

The April through September 4,034.60 ft (1229.75 m) minimum elevation was set, in part, to provide access to spawning areas below Anderson-Rose Dam (USFWS 2008). Spawning runs have occurred in years that Anderson-Rose Dam spills or releases water. Releases were required as provisions of earlier biological opinions (USFWS 1992, 2001, 2008). In 2006 and 2007, USFWS entered into an agreement with Tulelake Irrigation District to provide releases during the spawning season, but high flows in 2006 flushed out newly placed spawning gravel, and no further efforts were made to support spawning below the dam. As a result, in 2009, the 2008 biological opinion was amended and minimum flows were no longer required at Anderson-Rose Dam. Successful egg incubation and survival of larvae to swim-up below Anderson-Rose Dam has been infrequent in recent years and, because only two juvenile suckers were captured in Tule Lake in recent years, natural recruitment is thought to be very low or nonexistent (Hodge and Buettner 2008, USFWS 2008). The 2013 Revised Recovery Plan and the 2012 Final Rule for Critical Habitat both emphasize that agencies should continue to evaluate the feasibility of restoring spawning habitat and self-sustaining populations of suckers in Tule Lake. Reclamation has put suckers salvaged from the California portion of the Project into Sump 1A as part of their efforts to meet BiOp canal salvage requirements. This has occurred on a yearly basis since the early 1990s and numbers of suckers placed here varied from 2 to 625 between 2006 to 2010, and averaged 444 per year.

Water depths of Tule Lake Sumps 1A and 1B are shallow (mostly less than 4 ft [1.2 m] deep), and consequently there is a lack of adequate depth for suckers in large portions of the sumps. Additionally, gradual sedimentation is a potential threat to adult suckers that require water depths greater than 3 ft (1 m) to avoid predation by fish-eating birds, particularly pelicans (USFWS 2008).

During severe winters with thick ice cover, only small, isolated pockets of water with depths greater than 3 ft (1 m) exist in Sump 1A, increasing the risk of winter die-offs (USFWS 2008). However, the April 1 to September 30 minimum elevation of 4,034.60 ft (1229.75 m) was set, in part, to provide rearing habitat in Sump 1A, and the October 1 to March 31 minimum elevation of 4,034.00 ft (1229.56 m) was set to provide adequate winter depths for cover and to reduce the likelihood of fish die-offs from low DO concentrations below ice cover (USFWS 2008).

Water quality also is considered a threat to suckers in Tule Lake sumps. Tule Lake is classified as highly eutrophic (enriched) because of high concentrations of nutrients and resultant elevated aquatic plant productivity (Dileanis et al. 1996). Because Tule Lake is shallow and the nutrient content high, photosynthesis and respiration by aquatic plants and algae causes large fluxes in DO and pH. During the irrigation season, water reaching the sumps has been used multiple times on agricultural lands, which leads to increases in nutrient and pesticide concentrations (Orlob and Woods 1964, Dileanis et al. 1996).

Reclamation has documented surface temperatures up to 26 ºC (79º F); DO levels from supersaturation (>15.0 mg/L to near zero); and pH occasionally exceeds 10.0 (Reclamation 2009). During the winter, most inflow to Tule Lake is from localized runoff and water quality conditions are relatively good, except during prolonged periods of ice-cover when DO levels decline.

7.11.5 Conclusions Regarding the Capacity of the East Side Action Area to Support LRS and SNS Conservation

The focus of this discussion is to determine how the baseline condition in the action area affects the ability of multiple LRS and SNS populations to persist in a changing and adverse environment. To assess this, we compared the baseline conditions with what the recovery plan says are needed by the species to recover. The recovery strategy is intended to produce healthy self-sustaining populations by reducing mortality, restoring habitat, including spawning, larval, and juvenile habitats, and increasing connectivity between spawning and rearing habitats. Recovery also involves ameliorating adverse effects of degraded water quality, disease, and nonnative fish. The recovery goal is to produce naturally self-sustaining populations with healthy long-term demographic traits and trends.

Currently, Clear Lake has a much smaller population of LRS than UKL, but larger than any other water body, and a population of SNS on par with UKL. Suckers in Clear Lake are threatened by drought and resulting low lake levels, and predation by birds; however, water quality (including algal toxins) and disease are not known to be threats. Available information indicates that the Clear Lake sucker populations have remained viable under the current management regime, and we do not anticipate that this will change unless there is a prolonged drought more severe than occurred in the recent POR.

There is also a population of SNS in Gerber Reservoir. Similar to Clear Lake, the effects of fluctuating water levels on the SNS population there are not fully understood. Predation by birds, adverse water quality, algal toxins, and disease are not believed to be existing threats for this population. Available information indicates that the SNS population has remained viable under the current management regime, and we do not anticipate that will change unless there is a prolonged drought.

Both LRS and SNS reside in Sump 1A of Tule Lake but the majority is LRS. Neither species has a self-sustaining population in this water body. Drought, severe winter conditions and warm summer temperatures have the potential to cause low DO levels and threaten the species.

The Lost River is a highly altered system, which currently supports small sucker populations. This area provides recovery benefits by adding redundancy, but currently does not support self-sustaining populations because of habitat limitations.

8 EFFECTS OF THE ACTION ON LOST RIVER SUCKER AND SHORTNOSE SUCKER

8.1 Analytical Approach

8.1.1 Use of the Period of Record Hydrograph as a Tool to Analyze Project Effects

Because the proposed action is storage and delivery of water for Project purposes, analyzing hydrologic data, such as water levels in LRS and SNS habitats, is essential to our analysis of effects. However, because there is no way to know with certainty what future water conditions will be, for purposes of this analysis, we have relied upon historical data (i.e., the POR) in simulations to understand the likely range and distribution of elevations in Project reservoirs over the proposed 10-year term of Project operations. To be useful, the POR needs to be sufficiently long to capture a broad range of conditions and also needs to include recent data to capture any current trends. For this consultation, the POR hydrology data selected for Clear Lake and Gerber Reservoir were for calendar years 1902–2012 and 1925–2012, respectively. The POR hydrological data set for UKL relied upon in this analysis is the 31 years between October 1, 1980, and September 30, 2011. The shorter time period for the UKL POR was chosen because relevant data, specifically the reconstructed annual NRCS forecasts of water supply, which are necessary for modeling purposes, were only available beginning in the 1981 water year. Nevertheless, we conclude this POR sufficiently captures recent climatic trends and current water-use conditions, while also including a broad distribution of dry, average, and wet years.

Because Tule Lake is primarily a sump and gets most of its water from agricultural return flows, past water levels have been managed close to the minimum lake levels identified in the proposed action to reduce the risk of flooding. As a result, the POR water levels in Sump 1A of Tule Lake are less variable when compared with the Project's three primary water supply reservoirs: UKL, Clear Lake, and Gerber Reservoir.

8.1.2 Use of the KBPM Model as a Tool to Analyze Project Effects on Water Levels

To analyze potential effects of the proposed action, Reclamation and the Services used the KBPM to identify Klamath River and UKL hydrographs that would have occurred if the proposed action had been implemented at the start of the 1981 water year. The hydrographs and other modeled output are also used by the Services to anticipate likely future lake and river conditions in water years similar to those occurring in the POR. KBPM is based on Water Resource Integrated Modeling System software (WRIMS), a broadly accepted, generalized water-resources modeling software designed for evaluating river-basin scale water management alternatives. KBPM was developed jointly by Reclamation and the Services specifically for this consultation, and included input from Klamath Basin Indian tribes and the Klamath Project Water Users Association. A model is not available for the east side of the Project (i.e., the Lost River subbasin, including Clear Lake, Gerber Reservoir, and Tule Lake), so reservoir-specific water balance models based on the POR were used instead. For a detailed description of the KBPM model, see Appendix 4A in the BA (USBR 2012) and the description of the proposed action in the BA and in this BiOp.

The central pillar of the proposed action is that water management decisions are linked directly to real-time hydrologic and water use conditions. For the hydrologic and water use conditions experienced in the POR, the model simulates water management decisions under the proposed action and provides a reasonable approximation of outcomes for the different components of the system. A critical assumption of the effects analysis in this BiOp is that the hydrologic and water use conditions experienced in the POR, which provided the basis for the simulation of the proposed action and therefore of the effects analysis, will not change substantially over the term of this BiOp. If this assumption is violated to the extent that outcomes of implementing the proposed action do not exhibit central tendency and variability similar to the simulated outcomes, then operations may fall outside the analytical scope of this BiOp. The kinds of changes that could produce such a result include, but are not limited to:

- Sequencing of water years in terms of relative wetness and dryness. For example, two 3-year sequences of extremely dry – extremely dry – relatively wet (1991 – 1992 – 1993) and extremely dry – relatively wet – extremely dry (1992 – 1993 – 1994) exist in the POR, have been simulated, and are evaluated in this BiOp. However, a sequence of three back-to-back extremely dry years does not exist in the POR, has not been simulated, and has not been evaluated in this BiOp. Because the third year in a sequence of extremely dry years is likely to have outcomes more severe than what has been evaluated in this BiOp, such a sequence would be considered to be outside the scope of the BiOp.
- Declines in base flows during the July through September period.
- Continued shifts in the timing of spring run-off toward earlier in the year.
- Shifts in the pattern of consumptive water use within the Project, or the pattern or magnitude of water use above UKL.
- Shifts in the pattern or magnitude of net accretions between Link River Dam and Iron Gate Dam.
- Shifts in the pattern or magnitude of flows passing Harpold Dam.
- Changes to the elevation-capacity relationship for UKL.

For this BiOp, we assumed the PORs for the hydrology of the three primary Project reservoirs represent the range and distribution of elevations that are reasonably likely to occur over the 10-year consultation term (May 31, 2013 to March 31, 2023). However, we are also aware that, if trends continue, climate may be somewhat drier on average during the next 10 years than for the entire POR because drier conditions have prevailed recently and average inflows to UKL (1,081,000 acre-feet) during the decade between 2002 through 2011 are over 10 percent less than average inflow (1,246,000 acre-feet) during the entire POR.

We assume the following regarding the volume and timing of hydrologic data critical to the KBPM and implementation of the proposed action:

- Flow in the Williamson River and net inflow to UKL will be similar in magnitude, pattern, and sequence to that observed in the POR.
- Flow (return flow or direct release) from the east side to the west side of the Project will be within the ranges observed during the POR, and appropriate for water year conditions.
- Accretions to the Klamath River between Link River Dam and Iron Gate Dam will be within the ranges observed during the POR, and appropriate for water year conditions.

- Although the volume of Project water use may be different from the POR, particularly in years drier than average, the pattern of water use will be similar to the pattern observed during the POR.

We further assume Reclamation will incorporate the previous year's hydrologic data into the KBPM by March 31 each year to ensure the model remains current and reflects hydrologic trends. Data to be incorporated into the model annually include:

- UKL calculated daily net inflow (KBPM SV file variable I1_raw)
- UKL 3-day moving average net inflow (KBPM SV file variable I1)
- UKL cumulative inflow index (KBPM SV file variable)
- Cumulative precipitation index (KBPM SV file variable)
- Williamson River daily average flow (KBPM SV file variable)
- Lake Ewauna accretions (KBPM SV file variable I10)
- Keno Dam to Iron Gate Dam accretions (KBPM SV file variable I15)
- Flow diverted from the Lost River to the Lost River Diversion Channel at Wilson Dam (KBPM SV file variable I91)
- Area A2 winter runoff (KBPM SV file variable I131)
- NRCS forecasts for the Williamson River and UKL
- Project and Lower Klamath Lake NWR daily diversions and return flows

8.1.3 Sideboards for the Effects Analysis of Hydrologic Conditions

Our effects analysis for proposed management of UKL water levels is based on modeled output from the KBPM of the proposed action using hydrologic data from the POR. Modeled weekly UKL elevations for the POR are presented in tabular and graphical form in Appendix B. For Clear Lake and Gerber Reservoir, we compared minimum elevations and lake-level probability tables to the conservation needs of the species. For Tule Lake, the comparison was based on the proposed seasonal lake minimums. It is possible, but unlikely, that hydrologic conditions outside of the range, distribution, and sequence of conditions modeled for the proposed action could occur during the 10-year term of the proposed action. We cannot state with absolute certainty what hydrologic events will occur in the future, but we conclude that the past is the best predictor of the near future, (i.e., the next 10 years) and, therefore, we assume rare events in the past will be rare in the near future.

Reclamation's BA (Reclamation 2012) analyzed the hydrologic effects of the proposed action on LRS and SNS in UKL up to the 95 percent exceedance of lake elevations. As used by Reclamation, the 95 percent exceedance means that on any given date a specific lake elevation would be exceeded 95 percent of the time. This is equivalent to stating that there is a 95 percent probability of exceeding that specific lake elevation on a given date. For our analysis, we analyzed the effects of the proposed action over the full range of modeled results for each month, regardless of the probability of observing a specific elevation in the future. End-of-month elevations for Clear Lake and Gerber Reservoirs are presented in Appendix B. UKL end-of-month elevations are presented in Table 8.1 of section 0, *Effects of the Action*, of this BiOp.

The USFWS will evaluate whether implementation of the proposed action results in expected UKL elevations for each month of the year, based on the scatter of UKL elevations simulated by the KBPM. The scatter of modeled UKL elevations is presented in Figure 8.1 through Figure 8.12. For each month, Figure 8.1 through Figure 8.12 present simulated end-of-month UKL elevations graphed relative to observed cumulative net inflow into UKL. The scatter of UKL elevations shown on the monthly graphs defines the full range of elevations and effects in UKL analyzed by this BiOp. Therefore, the graphs show the full range of expected outcomes of implementing the proposed action, and provide a basis for evaluating whether hydrologic or operational conditions are forcing UKL elevations outside the modeled range of elevations and what has been analyzed in this BiOp.

In addition to the full range of expected UKL elevations, Figure 8.1 through Figure 8.12 also present minimum elevation thresholds developed by USFWS for UKL, based on the modeled results of the proposed action. The minimum elevation thresholds represent the extreme lower limits of elevations that should be observed in UKL during the term of the proposed action, with very limited exceptions that are described in more detail below. Assumptions underlying the thresholds include:

- The proposed action, including Conservation Measures, are implemented as described above and in Reclamation's BA (Reclamation 2012).
- Minimum elevation thresholds are not management targets. The thresholds define conditions that are outside the analyses conducted by USFWS for this BiOp.
- Elevations in UKL will exhibit the patterns and magnitudes expected for particular hydrologic and operational conditions modeled and described in the BA and in the *Effects of the Action* (section 8) of this BiOp.
- Elevations in UKL will be greater than the thresholds for all hydrologic conditions observed during the POR, except for discrete situations caused by rare winter events.
- The UKL elevation will be a specific distance above the threshold at the beginning of each irrigation season, based on winter and early spring conditions. As the irrigation season progresses, the distance between observed UKL elevations and the threshold should not progressively decline.

The minimum elevation thresholds define UKL elevations outside the scope of USFWS analyses, and provide for an early warning that aspects of hydrologic conditions or water resource management are out of balance compared with the simulated and intended results of implementing the proposed action. UKL elevations approaching a threshold indicate that Reclamation must identify the reasons for the unexpected elevations and consult with the Services regarding implementation of potential adaptive management actions to prevent violation of the threshold. However, if adaptive management is unsuccessful at avoiding threshold violations and the USFWS does not accept the rationale for the violation or mitigation of the effects, the action will be declared to be outside of the USFWS analysis and may trigger reinitiation of consultation.

The minimum elevation thresholds for UKL were developed by graphing the modeled month-end UKL elevations as a function of cumulative net inflow into UKL. Thresholds define the lower edge of the scatter of UKL elevations simulated in the proposed action. They were developed by selecting points on the lower edge of the scatter, allowing for a 0.1 foot buffer (less than 1 m), and fitting one or more straight lines to those points to encompass the range of observed net inflows. No buffer was used in the driest years.

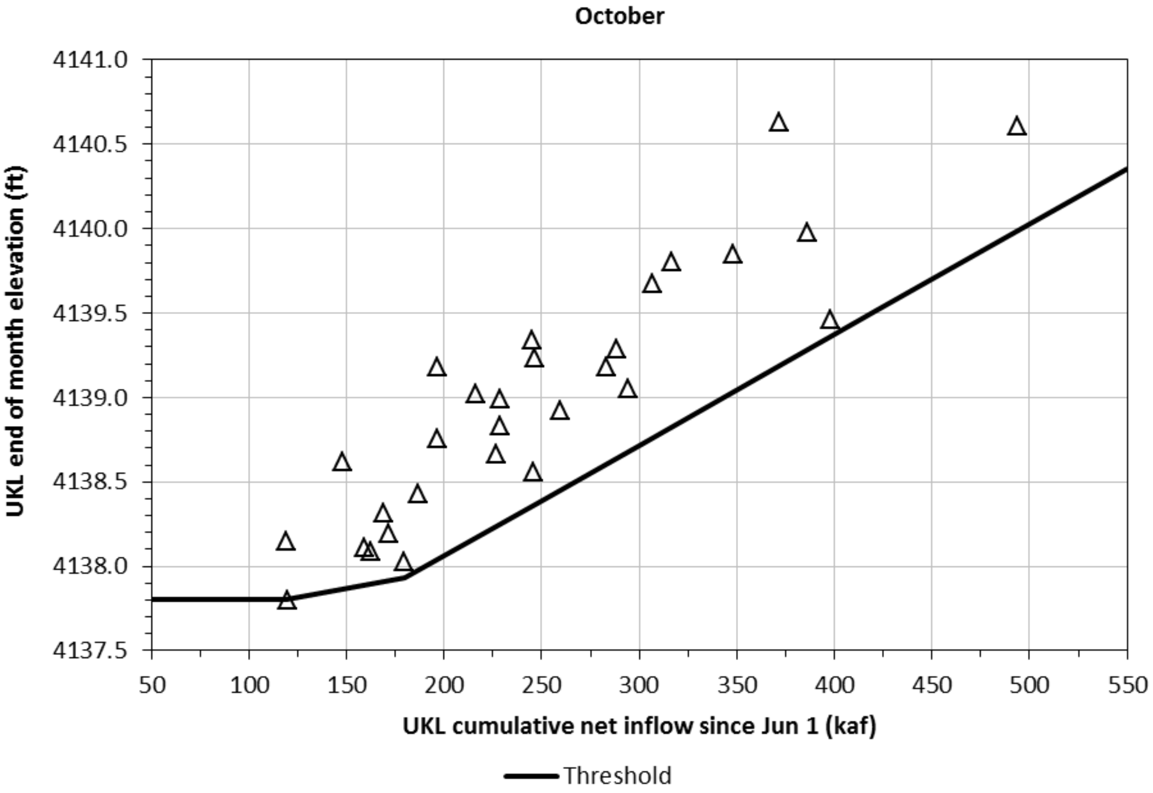


Figure 8.1 UKL elevations at the end of October (kaf = thousand acre-feet).

For cumulative net inflow values less than 119,000 acre-feet since June 1, the minimum UKL elevation is 4,137.80 ft (1,261.20 m).

For cumulative net inflow values between 119,000 and 180,000 acre-feet, the equation determining the UKL elevation threshold = 0.002169x + 4137.5394 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between greater than 180,000 acre-feet, the equation determining the UKL elevation threshold = 0.00655x + 4136.752 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

The points on the October graph defining the threshold, from low to high, are from water years 1993, 1982, and 2000.

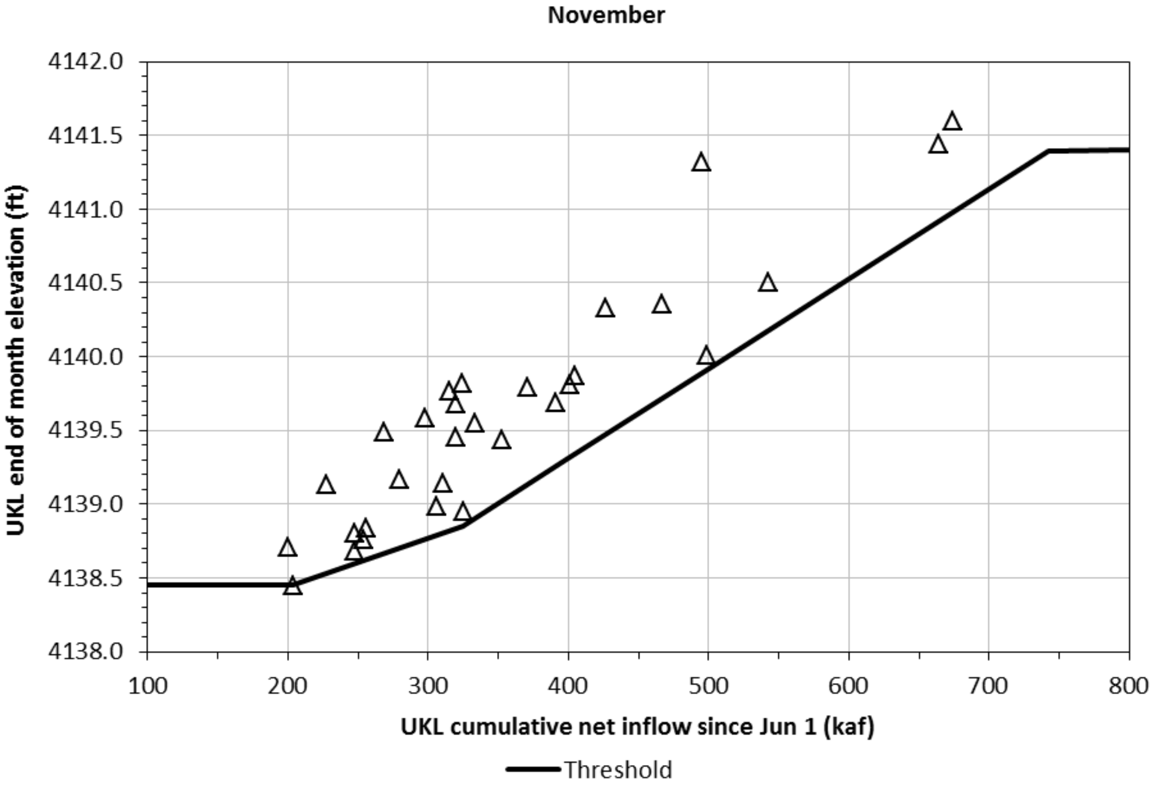


Figure 8.2. UKL elevations at the end of November (kaf = thousand acre-feet).

For cumulative net inflow values less than 203,500 acre-feet since June 1, the minimum UKL elevation is 4,138.45 ft (1,261.40 m).

For cumulative net inflow values between 203,500 and 325,000 acre-feet, the equation determining the UKL elevation threshold = 0.003348x + 4137.7653 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between 325,000 and 742,000 acre-feet, the equation determining the UKL elevation threshold = 0.006097x + 4136.8721 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values greater than 742,000 acre-feet since June 1, the minimum UKL elevation is 4,141.40 ft (1,262.30 m).

The points on the November graph defining the threshold, from low to high, are from water years 1993, 1990, and 2000.

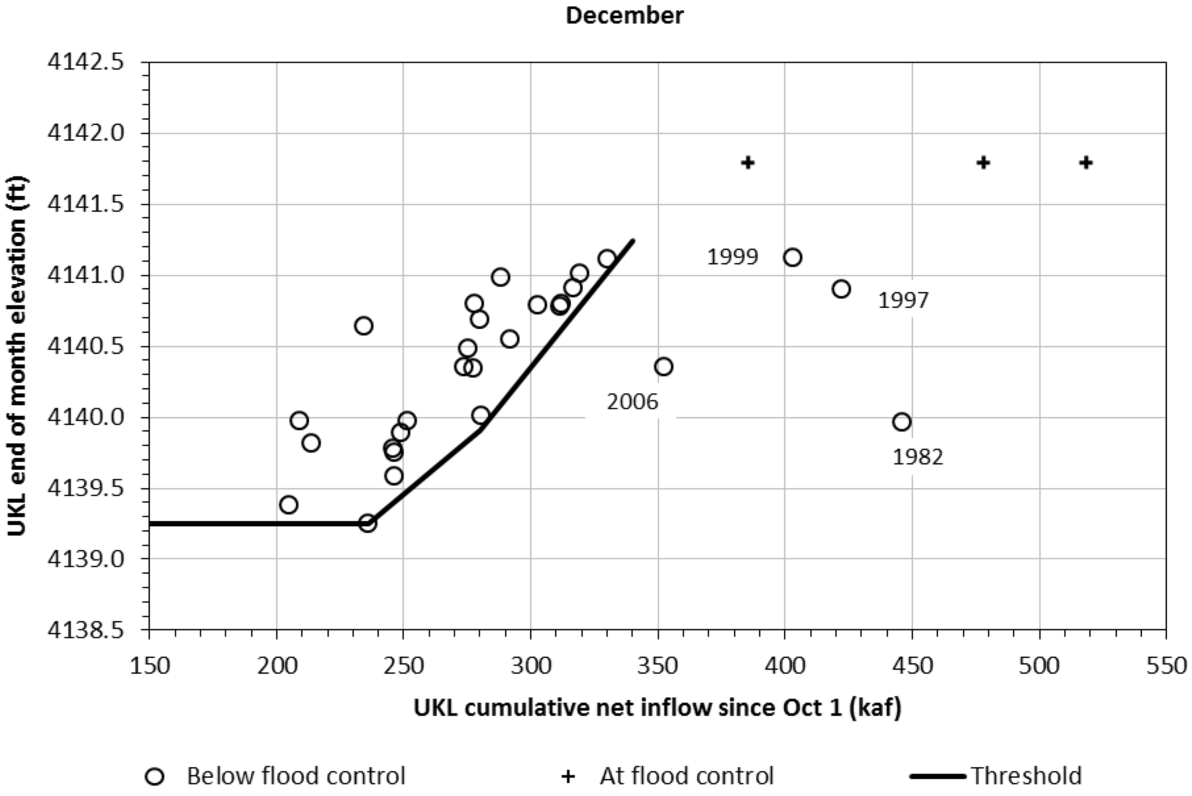


Figure 8.3. UKL elevations at the end of December (kaf = thousand acre-feet).

In December, water years 1982, 1997, 1999, and 2006 are considered outliers because the UKL elevation was less than expected for the cumulative inflow in those years, based on threshold shown in Figure 8.3. In addition to higher cumulative inflows than any other years, these 4 years also had high relative inflow during December compared to the POR. This suggests a rapid early-season snow melt or rain on snow event in which flood prevention spills would likely be initiated. In similar situations during implementation of the proposed action, Reclamation will consult with the Services regarding reasons for the lower than anticipated UKL elevations. The Services and Reclamation will determine if UKL is on a trajectory to fill later in the winter, based on current and forecasted conditions or if adaptive management actions must be taken. Therefore, if the cumulative net inflow to UKL since October 1 is greater than 340,000 acre-feet, no threshold applies if the Services and Reclamation agree that UKL is on a trajectory to fill later in the winter, or adaptive management actions will result in sufficient UKL elevations in the spring.

For cumulative net inflow values less than 236,000 acre-feet since October 1, the minimum UKL elevation is 4,139.25 ft (1,261.64 m).

For cumulative net inflow values between 236,000 and 280,500 acre-feet, the equation determining the UKL elevation threshold = 0.015x + 4135.7037 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values between 280,500 and 340,000 acre-feet, the equation determining the UKL elevation threshold = 0.02223x + 4133.6843 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values greater than 340,000 acre-feet since October 1, the minimum UKL elevation will be determined based on KBPM simulated results and observed hydrologic conditions.

The points on the December graph defining the threshold, from low to high, are from water years 1993, 2002, and 1986.

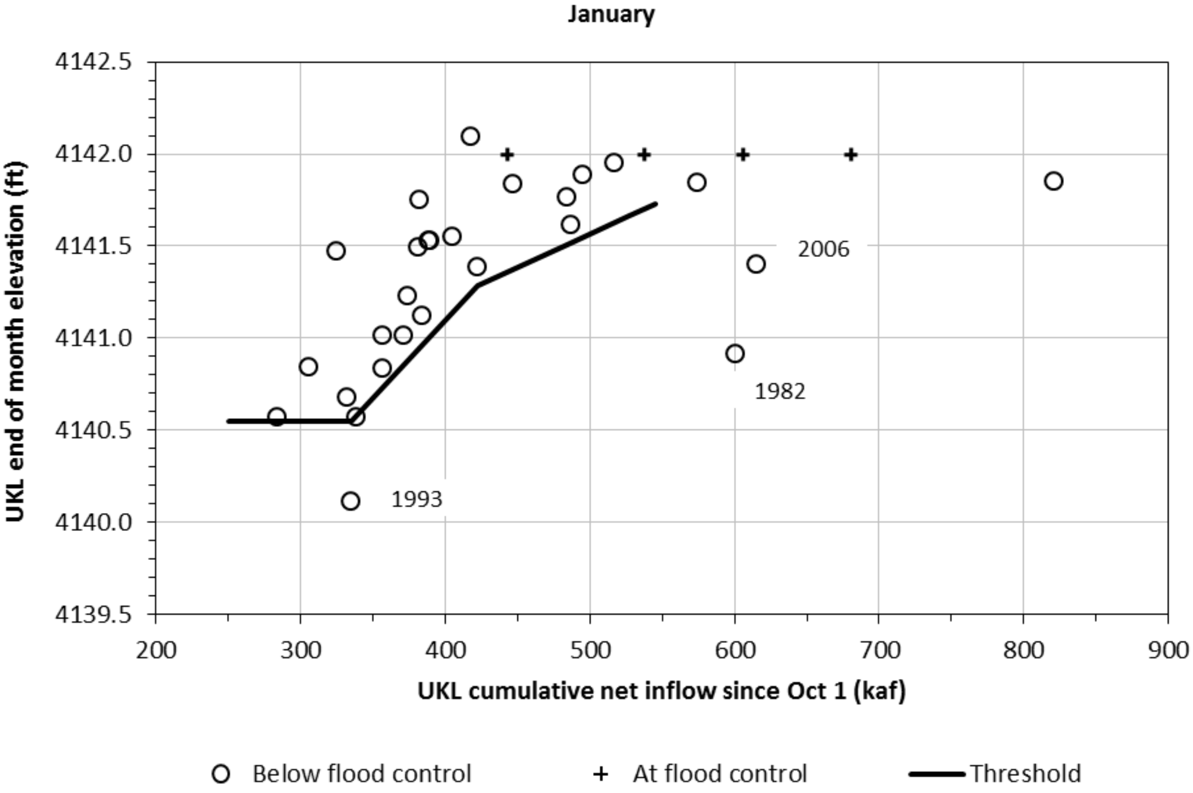


Figure 8.4. UKL elevations at the end of January (kaf = thousand acre-feet).

In January, water years 1982, 1993, and 2006 are considered outliers because the UKL elevation was less than expected for the cumulative inflow in those years, based on threshold shown in Figure 8.4. January 1993 was a relatively low inflow month and followed the extremely dry 1992 water year. However, flood control releases were modeled by the end of March 1993 because a large snowpack had accumulated. Similar to December, water years 1982 and 2006 had high cumulative inflows and 2006 also had high inflow during January compared to the POR. In similar situations during implementation of the proposed action, Reclamation will consult with the Services regarding reasons for the lower than anticipated UKL elevations. The

Services and Reclamation will determine if UKL is on a trajectory to fill later in the winter, based on current and forecasted conditions or if adaptive management actions must be taken. Therefore, if the cumulative net inflow to UKL since October 1 is greater than 545,000 acre-feet, no threshold applies if the Services and Reclamation agree that UKL is on a trajectory to fill later in the winter, or adaptive management actions will result in sufficient UKL elevations in the spring.

For cumulative net inflow values less than 338,000 acre-feet since October 1, the minimum UKL elevation is 4,140.58 ft (1,262.05 m).

For cumulative net inflow values between 338,000 and 422,000 acre-feet, the equation determining the UKL elevation threshold = 0.008452x + 4137.7185 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values between 422,000 and 545,000 acre-feet, the equation determining the UKL elevation threshold = 0.003598x + 4139.7681 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values greater than 545,000 acre-feet since October 1, the minimum UKL elevation will be determined based on KBPM simulated results and observed hydrologic conditions.

The points on the January graph defining the threshold, from low to high, are from water years 1992, 1995, 2002, and 1998.

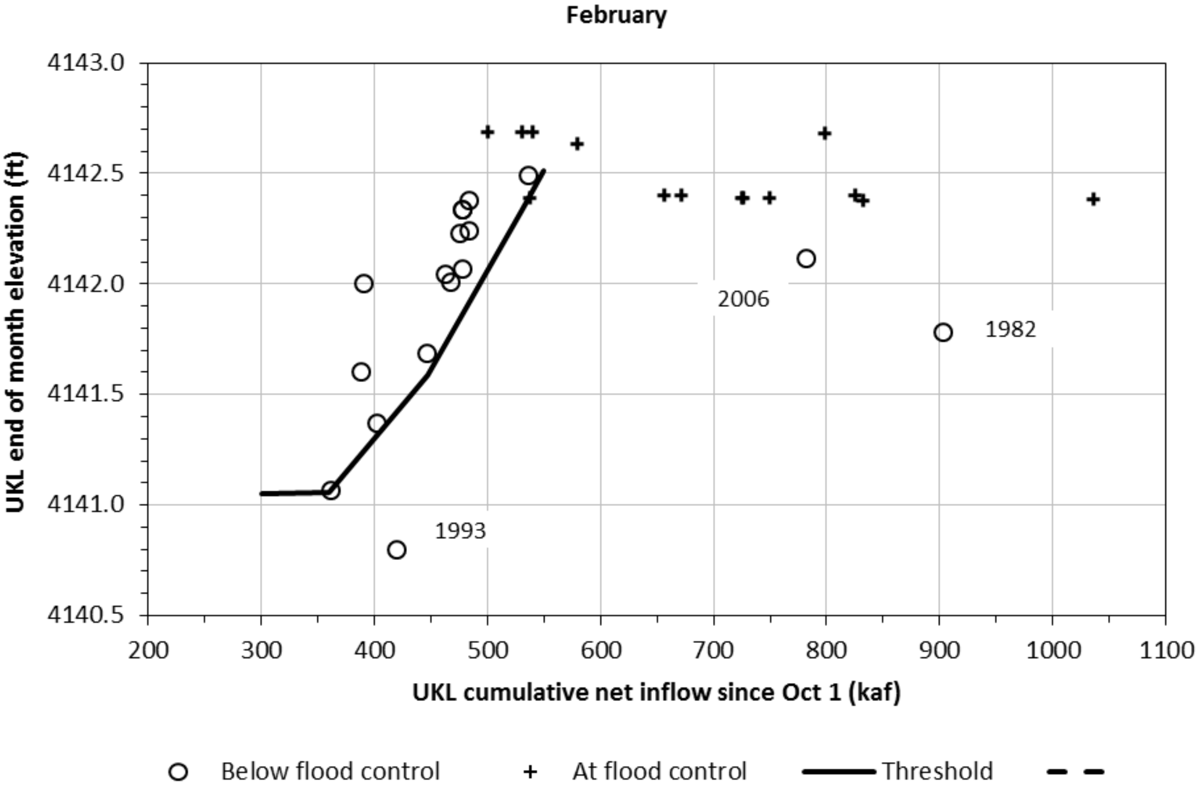


Figure 8.5. UKL elevations at the end of February (kaf = thousand acre-feet).

In February, water years 1982, 1993, and 2006 are considered outliers because the UKL elevation was less than expected for the cumulative inflow in those years, based on threshold shown in Figure 8.5. Circumstances for these years were similar to those described for January. In similar situations during implementation of the proposed action, Reclamation will consult with the Services regarding reasons for the lower than anticipated UKL elevations. The Services and Reclamation will determine if UKL is on a trajectory to fill later in the winter, based on current and forecasted conditions or if adaptive management actions must be taken. Therefore, if the cumulative net inflow to UKL since October 1 is greater than 550,000 acre-feet, no threshold applies if the Services and Reclamation agree that UKL is on a trajectory to fill later in the winter, or adaptive management actions will result in sufficient UKL elevations in the spring.

For cumulative net inflow values less than 362,000 acre-feet since October 1, the minimum UKL elevation is 4,141.07 ft (1,262.20 m).

For cumulative net inflow values between 362,000 and 447,000 acre-feet, the equation determining the UKL elevation threshold = 0.006125x + 4138.8493 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values between 447,000 and 550,000 acre-feet, the equation determining the UKL elevation threshold = 0.00896x + 4137.5819 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.
For cumulative net inflow values greater than 550,000 acre-feet since October 1, the minimum UKL elevation will be determined based on KBPM simulated results and observed hydrologic conditions.

The points on the February graph defining the threshold, from low to high, are from water years 1992, 2005, and 2010.

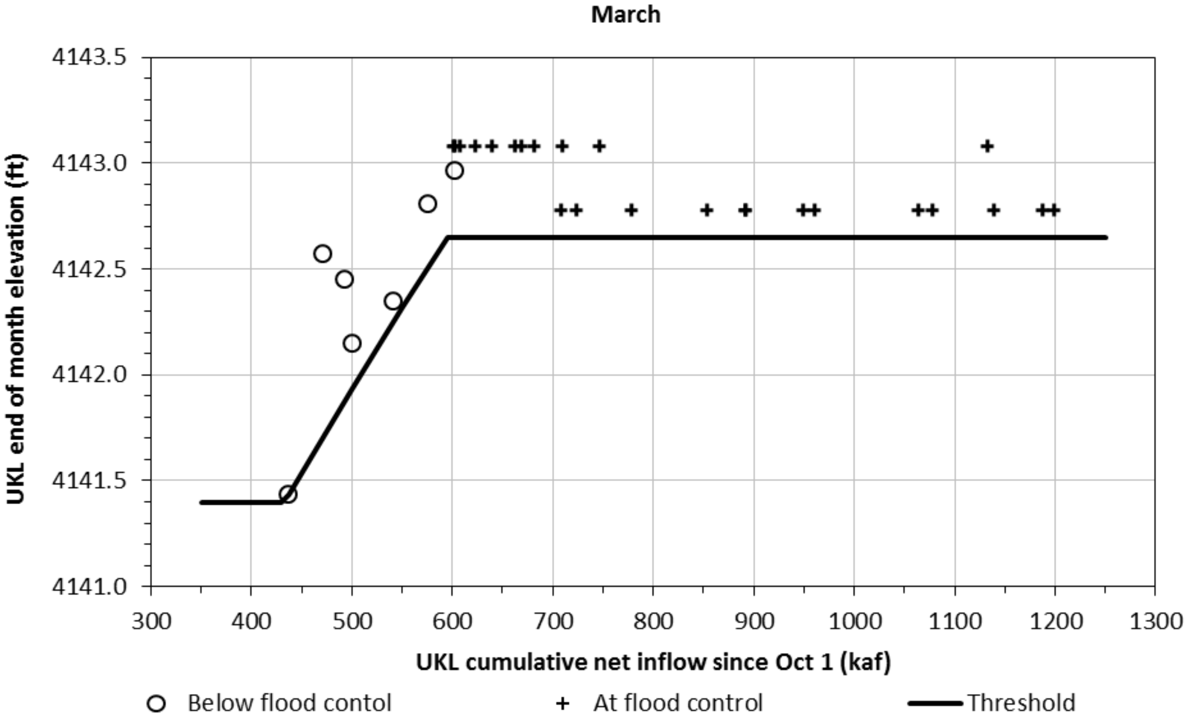


Figure 8.6. UKL elevations at the end of March (kaf = thousand acre-feet).

For cumulative net inflow values less than 437,000 acre-feet since October 1, the minimum UKL elevation is 4,141.43 ft (1,262.31 m).

For cumulative net inflow values between 437,000 and 595,000 acre-feet, the equation determining the UKL elevation threshold = 0.007857x + 4138.001 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values greater than 595,000 acre-feet since October 1, the minimum UKL elevation is 4,142.65 ft (1,262.68 m).

The points on the March graph defining the threshold, from low to high, are from water years 1991 and 1994, followed by the flood control elevation.

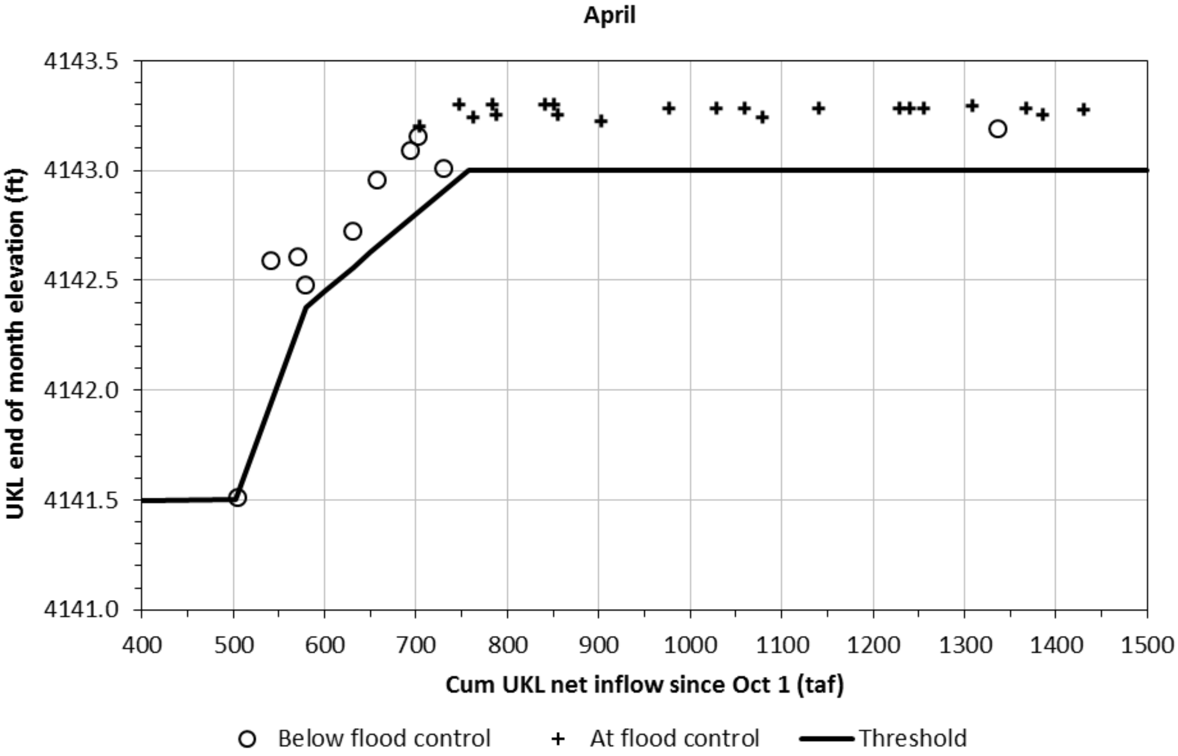


Figure 8.7. UKL elevations at the end of April (kaf = thousand acre-feet).

For cumulative net inflow values less than 504,000 acre-feet since October 1, the minimum UKL elevation is 4,141.51 ft (1,262.33 m).

For cumulative net inflow values between 504,000 and 579,000 acre-feet, the equation determining the UKL elevation threshold = 0.01154x + 4135.6961 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values between 579,000 and 730,000 acre-feet, the equation determining the UKL elevation threshold = 0.00349x + 4140.3572 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values greater than 730,000 acre-feet since October 1, the minimum UKL elevation is 4,143.00 ft (1,262.79 m).

The points on the April graph defining the threshold, from low to high, are from water years 1992, 2005, and 2003.

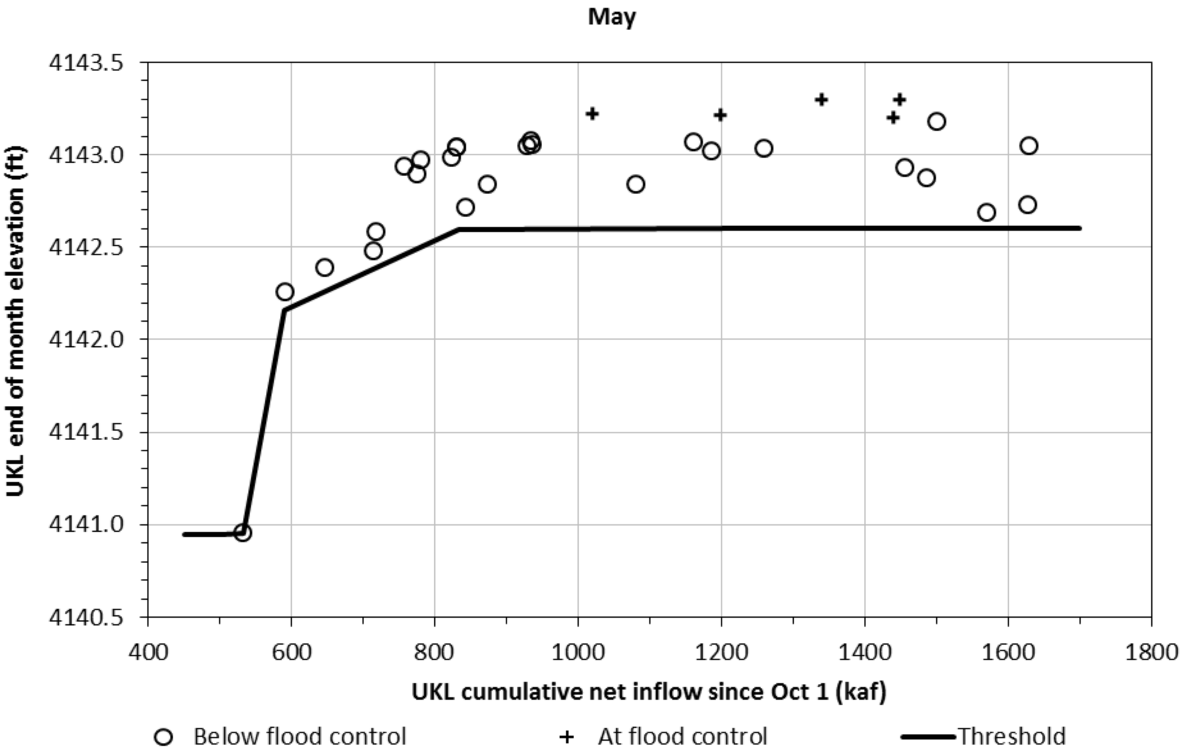


Figure 8.8. UKL elevations at the end of May (kaf = thousand acre-feet).

For cumulative net inflow values less than 532,000 acre-feet since October 1, the minimum UKL elevation is 4,140.96 ft (1,262.17 m).

For cumulative net inflow values between 532,000 and 590,000 acre-feet, the equation determining the UKL elevation threshold = 0.02075x + 4129.9131 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values between 590,000 and 843,000 acre-feet, the equation determining the UKL elevation threshold = 0.001804x + 4141.0954 where x = the cumulative net inflow into UKL since October 1 in thousand acre-feet.

For cumulative net inflow values greater than 843,000 acre-feet since October 1, the minimum UKL elevation is 4,142.60 ft (1,262.66 m).

The points on the May graph defining the threshold, from low to high, are from water years 1992, 1994, 2003, and 1983.

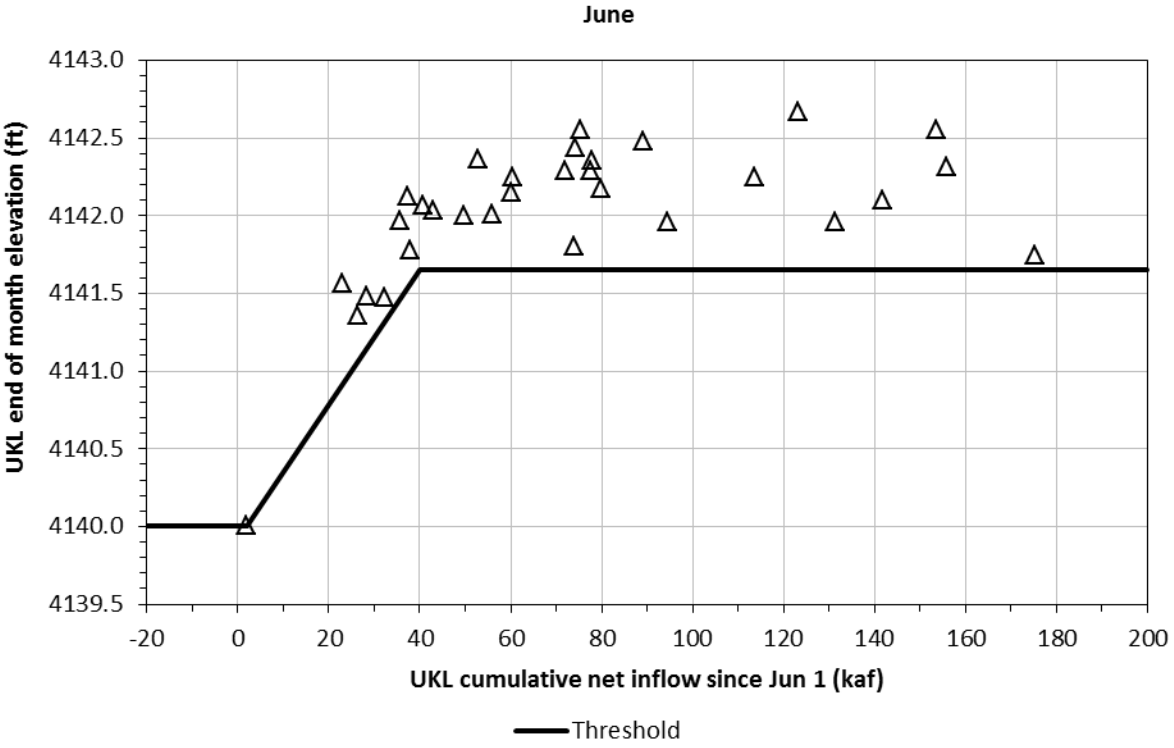


Figure 8.9. UKL elevations at the end of June (kaf = thousand acre-feet).

For cumulative net inflow values less than 2,000 acre-feet since June 1, the minimum UKL elevation is 4,140.00 ft (1,261.87 m).

For cumulative net inflow values between 2,000 and 38,000 acre-feet, the equation determining the UKL elevation threshold = 0.04509x + 4139.9159 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values greater than 38,000 acre-feet since June 1, the minimum UKL elevation is 4,141.65 ft (1,262.38 m).

The points on the June graph defining the threshold, from low to high, are from water years 1992, 1991, 2002, and 1983.

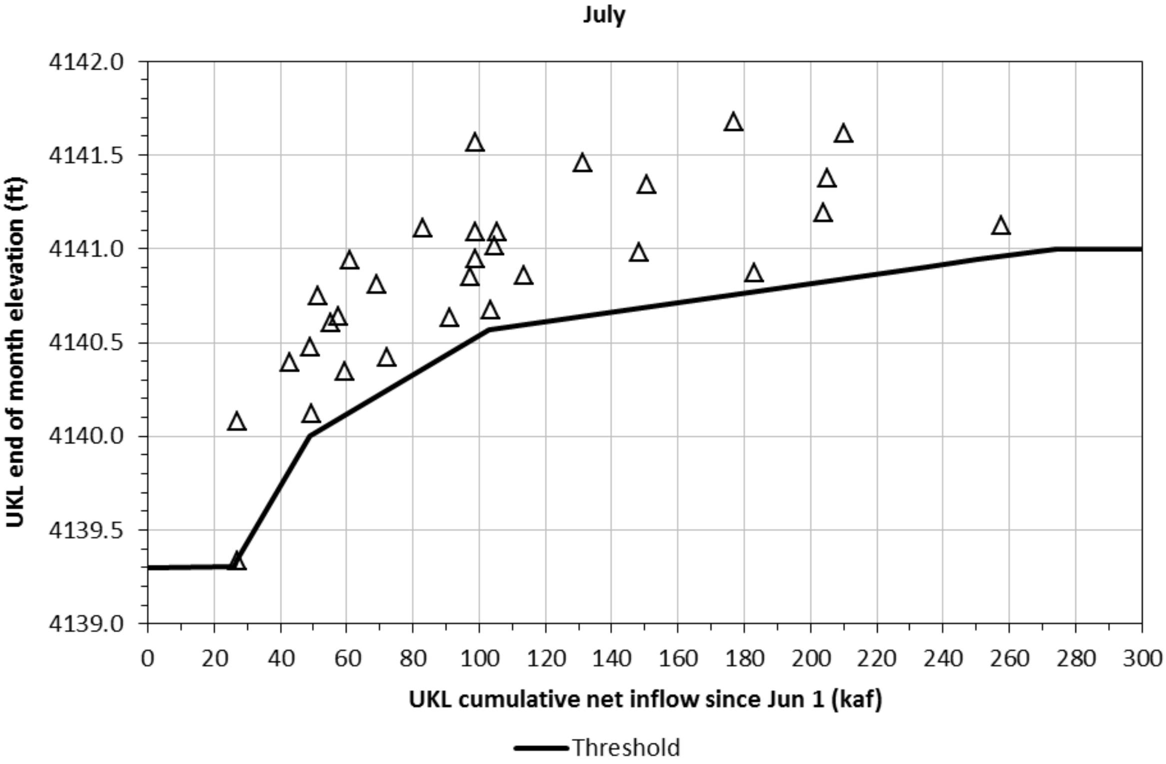


Figure 8.10. UKL elevations at the end of July (kaf = thousand acre-feet).

For cumulative net inflow values less than 27,000 acre-feet since June 1, the minimum UKL elevation is 4,139.34 ft (1,261.67 m).

For cumulative net inflow values between 27,000 and 49,500 acre-feet, the equation determining the UKL elevation threshold = 0.0302x + 4138.5227 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between 49,500 and 103,000 acre-feet, the equation determining the UKL elevation threshold = 0.01026x + 4139.5112 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between 103,000 and 274,000 acre-feet, the equation determining the UKL elevation threshold = 0.002517x + 4140.3122 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values greater than 274,000 acre-feet since June 1, the minimum UKL elevation is 4,141.00 ft (1,262.18 m).

The points on the July graph defining the threshold, from low to high, are from water years 1992, 2003, 2008, and 1999.

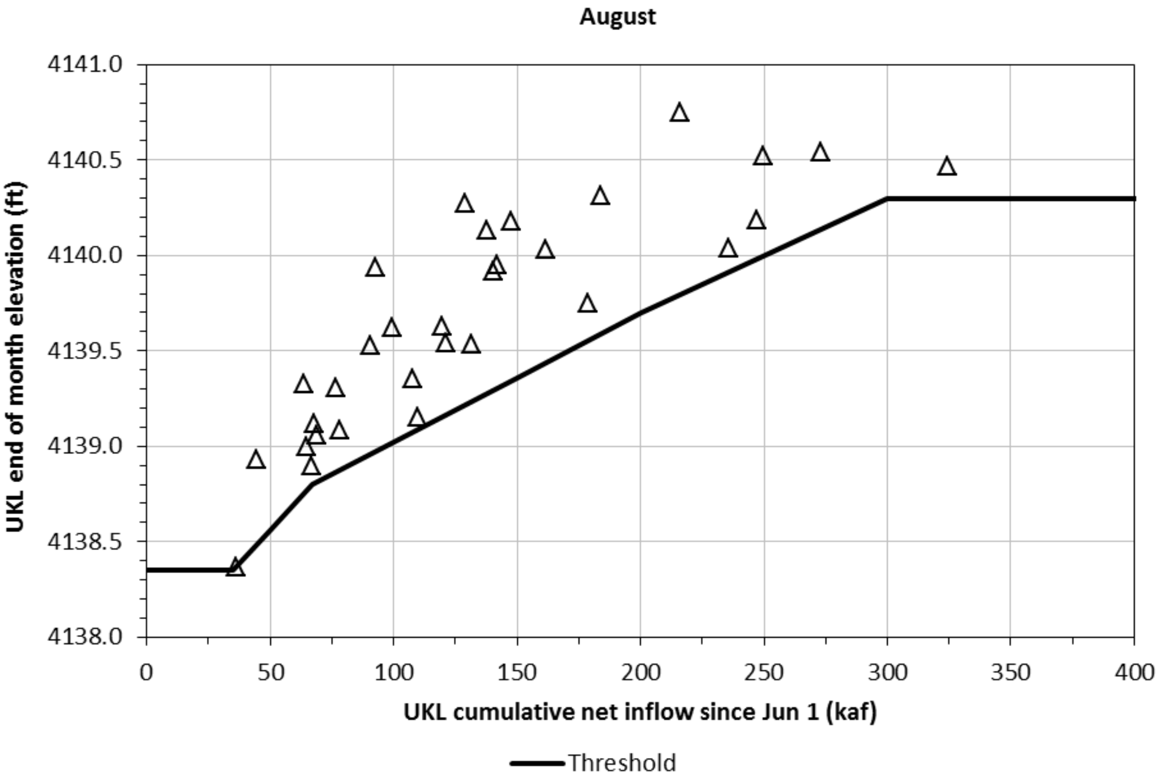


Figure 8.11. UKL elevations at the end of August (kaf = thousand acre-feet).

For cumulative net inflow values less than 36,000 acre-feet since June 1, the minimum UKL elevation is 4,138.37 ft (1,261.38 m).

For cumulative net inflow values between 36,000 and 67,000 acre-feet, the equation determining the UKL elevation threshold = 0.01419x + 4137.8517 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between 67,000 and 300,000 acre-feet, the equation determining the UKL elevation threshold = 0.006736x + 4138.3492 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values greater than 300,000 acre-feet since June 1, the minimum UKL elevation is 4,140.30 ft (1,261.96 m).

The points on the August graph defining the threshold, from low to high, are from water years 1992, 2003, 2011, and 1983.

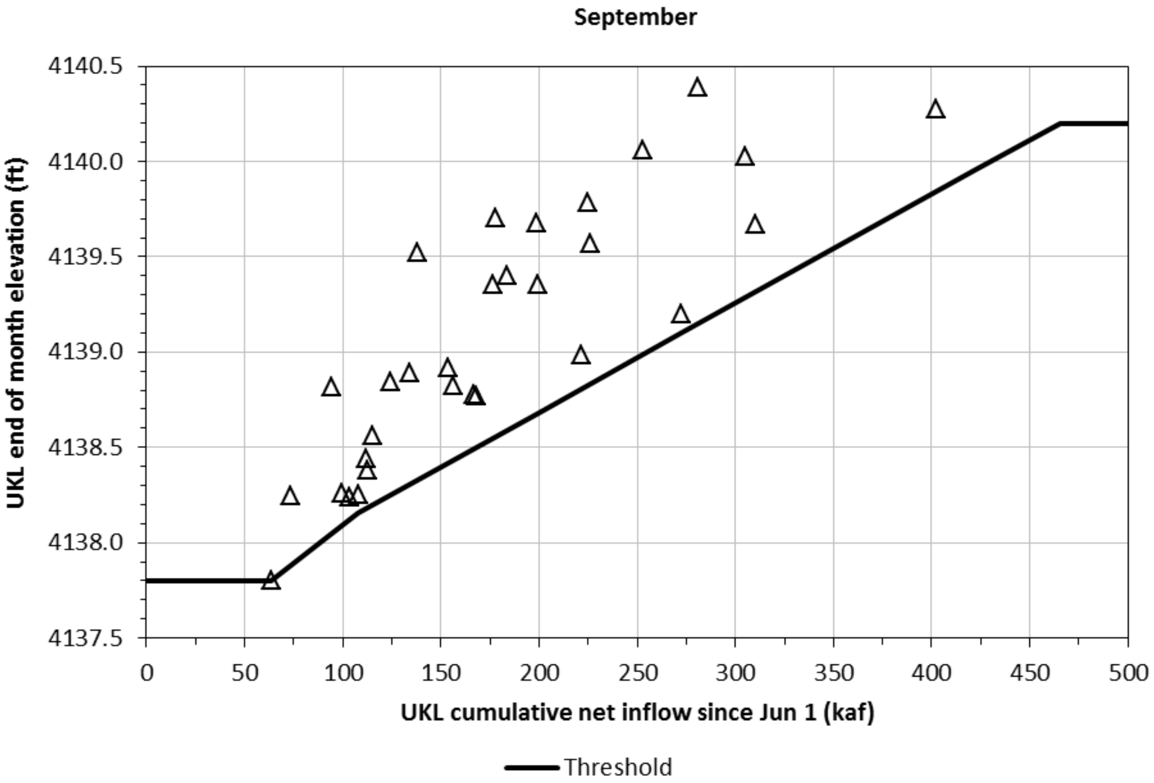


Figure 8.12. UKL elevations at the end of September (kaf = thousand acre-feet).

For cumulative net inflow values less than 64,000 acre-feet since June 1, the minimum UKL elevation is 4,137.80 ft (1,261.20m).

For cumulative net inflow values between 64,000 and 109,000 acre-feet, the equation determining the UKL elevation threshold = 0.008006x + 4137.2905 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values between 109,000 and 465,000 acre-feet, the equation determining the UKL elevation threshold = 0.005727x + 4137.5369 where x = the cumulative net inflow into UKL since June 1 in thousand acre-feet.

For cumulative net inflow values greater than 465,000 acre-feet since June 1, the minimum UKL elevation is 4,140.20 ft (1,261.93 m).

The points on the September graph defining the threshold, from low to high, are from water years 1992, 1981, and 2011.

8.2 Key Assumptions for the Effects Analysis

In developing this analysis, we needed to make a number of key assumptions because of a lack of information. If these assumptions prove false or warrant changes during Project implementation it could affect the validity of this analysis, and potentially trigger re-initiation of ESA Section 7 consultation if it results in effects that were not considered herein.

The following assumptions were used in completing this analysis:

- Reclamation will operate the Klamath Project and implement Conservation Measures according to the description of the proposed action presented in their BA, as amended.
- We assume Reclamation will ensure that appropriate coordination and oversight occurs with operators of Project facilities, including PacifiCorp and irrigation and drainage districts, so that water levels in UKL will exhibit the patterns and magnitudes expected for particular hydrologic and operational conditions modeled and described in the BA and in this BiOp. Furthermore, we assume Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A will be operated within the historic ranges observed during the POR and analyzed in this BiOp.
- Reclamation will ensure that hydrologic data used to manage Project reservoirs are accurate. This specifically includes UKL bathymetry data, especially bottom elevations in areas frequented by adult suckers, such as Pelican Bay, and the elevation-capacity relationship that Reclamation uses to determine the storage in UKL associated with elevations greater than 4,136.00 ft. Additionally, we assume that water-balance models for Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A provide reasonable simulations of the physical processes they simulate.
- Reclamation will implement and complete the 10 studies described in their 2013 annual work plan, dated March 5, 2013.
- The PORs for the hydrology of the three primary Project reservoirs represent the range and distribution of elevations that are reasonably likely to occur over the 10-year consultation term (May 31,2013–March 2023).
- Reclamation will provide the staff and funding necessary to implement the conservation measures proposed in the BA.
- Revised bottom elevations at the entrance to Pelican Bay are accurate.
- Water balance models for Clear Lake and Gerber Reservoir provide reasonable simulations of the physical processes they model.
- Any deviation from the formulaic approach intended to improve conditions for ESA-listed species cannot create adverse effects greater than was analyzed in this BiOp, as is stated in the BA, Section 4.3.4.2 (p. 4-51).

The foundation of an ESA Section 7(a)(2) analysis is an accurate characterization of the effects likely to be caused by the Proposed Action on listed species and critical habitat. For ongoing water projects, such as the Klamath Project, determining the effects of the Proposed Action on listed species and critical habitat is complicated because Project-affected lakes and reservoirs experience varying water levels and water quality conditions affecting listed species and their habitats as a result of both Project-related discretionary management actions and unrelated natural and man-caused changes in inflows and outflows and the effects of pre-existing infrastructure that have collectively altered the natural hydrology of the action area. Currently, best available information and our technical capability are insufficient to precisely distinguish between the effects likely to be caused by the Proposed Action to water levels and quality in the action area and such effects caused by other factors, such as climate, wetland alterations, water diversions by non-Project users, and pre-existing water management infrastructure. For those reasons, a more generalized approach has been used to complete the following effects analysis that reflects the focus of Project-related water management on storage from October to April and delivery from April to October. In general, water levels and the quantity and quality of sucker habitat in Project lakes and reservoirs are likely to be higher in the spring and lower in the summer than under a no-Project situation, except in water years with an exceptional snowpack and relatively cool, wet summers where water levels and quality are likely to be high during the spring and summer.

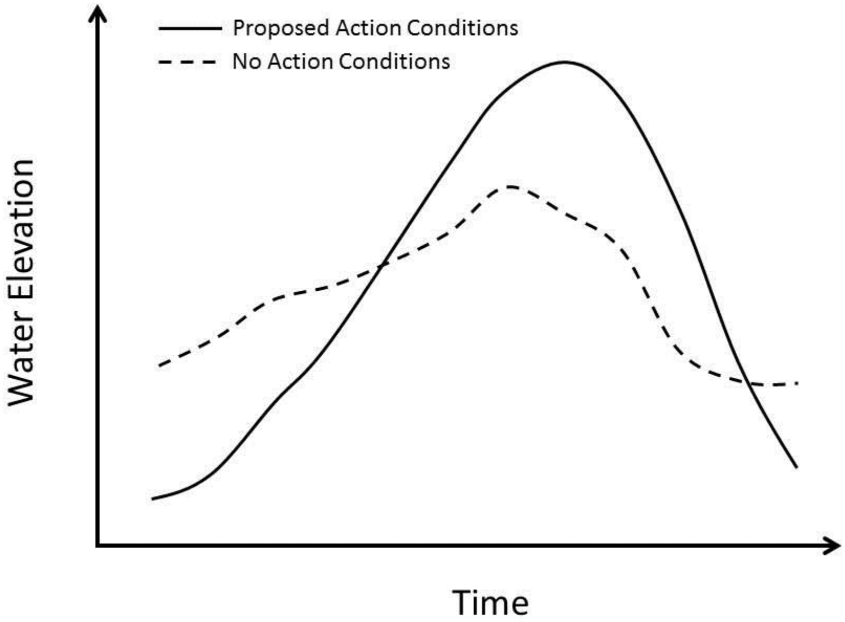


Figure 8.13. Generalized annual pattern of water-level changes in the UKL and Gerber Reservoir and in Clear Lake over a longer time period as a result of the proposed action compared to what would occur if the proposed action were not implemented. In general, water levels are more variable under the proposed action in comparison to the no-action condition.

8.2.1 Comparison of the Effects of the Proposed Action to the Species Conservation Needs

The following analysis relies on the findings presented in the *Status of the Species* analysis above for the LRS and the SNS, especially with respect to their conservation needs, to express the significance of anticipated effects of the proposed Project on these species.

8.3 Effects of the Proposed Action to the UKL Recovery Units of LRS and SNS

As discussed above in section 7, *Status of the Species*, the Revised Recovery Plan for the LRS and the SNS (USFWS 2013) identifies two recovery units for both species: (1) the UKL recovery unit; and (2) the Lost River sub-basin recovery unit. This analysis also relies on the survival and recovery function assigned to each of these units to express the significance of anticipated effects of the proposed Project on these species

8.3.1 Effects of the Proposed Action to LRS and SNS Populations in UKL

As described in section 7, *Status of the Species*, of this BiOp, UKL supports a population of the SNS, and the largest population of the LRS. The proposed action is likely to affect habitat availability for all LRS and SNS life-history stages, including embryos, pre- and post-swim-up larvae, age-0 juveniles, older juveniles, and adults. Each sucker life stage has specific habitat needs and specific seasonal time periods when those habitats are used. This analysis evaluates the effects that the proposed management of UKL surface elevations and the resultant water depths are likely to have on the quality and quantity of habitat for each LRS and SNS life-history stage in UKL.

8.3.1.1 Effects to Shoreline Spawning Habitat

LRSs (and a few SNSs) spawn at shoreline springs along the east side of UKL beginning as early as March and extending through May, with a peak in April (Buettner and Scoppettone 1990, Barry et al. 2007b, Janney et al. 2009, Hewitt et al. 2012). One objective of the proposed action is to fill UKL each spring to ensure there is an adequate water supply to meet irrigation and environmental needs, including LRS and SNS and coho salmon, and consequently maximum lake elevations are expected to be reached each year by April, or sometimes in May (Table 8.1 and Table 8.2).

Table 8.1 UKL end-of-month surface elevations in ft for the POR water years 1981 through 2011, based on KBPM modeling of the proposed action (Reclamation 2012, Table 7-1).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980										4,139.1	4,139.7	4,140.8
1981	4,141.7	4,142.7	4,143.1	4,143.2	4,143.0	4,142.2	4,140.8	4,139.2	4,138.2	4,138.0	4,139.0	4,139.9
1982	4,140.9	4,141.8	4,142.8	4,143.3	4,142.8	4,142.2	4,141.7	4,140.8	4,140.4	4,140.6	4,141.3	4,141.8
1983	4,142.0	4,142.4	4,142.8	4,143.2	4,142.7	4,141.8	4,141.2	4,140.5	4,140.3	4,140.6	4,141.4	4,141.8
1984	4,142.0	4,142.4	4,142.8	4,143.3	4,143.1	4,142.3	4,141.4	4,140.5	4,140.6	4,141.2	4,141.6	4,141.8
1985	4,142.0	4,142.4	4,142.8	4,143.3	4,143.0	4,142.3	4,140.9	4,140.1	4,140.1	4,139.9	4,140.3	4,141.1
1986	4,141.9	4,142.7	4,143.1	4,143.3	4,143.2	4,142.3	4,141.1	4,140.0	4,139.8	4,139.8	4,140.3	4,141.0
1987	4,141.8	4,142.6	4,143.1	4,143.3	4,143.1	4,142.4	4,141.6	4,140.3	4,139.7	4,139.4	4,139.8	4,141.0
1988	4,142.1	4,142.7	4,143.1	4,143.2	4,143.0	4,142.6	4,141.2	4,139.7	4,138.9	4,138.8	4,139.7	4,140.7
1989	4,141.5	4,142.2	4,142.8	4,143.3	4,143.0	4,142.1	4,140.5	4,139.2	4,138.8	4,138.6	4,138.9	4,139.8
1990	4,141.0	4,142.0	4,143.1	4,143.1	4,142.9	4,142.1	4,141.0	4,140.0	4,139.5	4,139.2	4,139.5	4,140.0
1991	4,140.8	4,141.6	4,142.4	4,142.6	4,142.4	4,141.5	4,140.5	4,139.4	4,138.9	4,138.6	4,139.1	4,139.8
1992	4,140.6	4,141.1	4,141.4	4,141.5	4,141.0	4,140.1	4,139.4	4,138.4	4,137.8	4,137.8	4,138.4	4,139.2
1993	4,140.1	4,140.8	4,142.7	4,143.3	4,143.1	4,142.7	4,141.4	4,140.4	4,139.6	4,139.7	4,139.8	4,140.6
1994	4,141.5	4,142.0	4,142.6	4,142.6	4,142.3	4,141.4	4,140.1	4,138.9	4,138.3	4,138.1	4,138.7	4,139.4
1995	4,140.5	4,142.0	4,143.1	4,143.3	4,143.2	4,142.5	4,141.5	4,140.2	4,139.4	4,139.2	4,139.5	4,140.8
1996	4,141.9	4,142.4	4,142.8	4,143.3	4,143.3	4,142.5	4,141.1	4,140.0	4,139.4	4,139.3	4,139.9	4,140.9
1997	4,141.9	4,142.4	4,142.8	4,143.3	4,143.2	4,142.3	4,141.2	4,140.2	4,139.7	4,139.2	4,139.7	4,140.5
1998	4,141.6	4,142.4	4,142.8	4,143.2	4,143.3	4,142.6	4,141.7	4,140.6	4,140.0	4,140.0	4,140.5	4,141.1
1999	4,141.8	4,142.4	4,142.8	4,143.3	4,143.0	4,142.0	4,140.9	4,140.2	4,139.7	4,139.4	4,140.0	4,140.8
2000	4,141.8	4,142.4	4,142.8	4,143.3	4,143.2	4,142.2	4,140.9	4,139.6	4,139.4	4,138.9	4,139.4	4,140.3
2001	4,141.2	4,142.0	4,142.8	4,143.0	4,142.6	4,141.6	4,140.4	4,139.0	4,138.3	4,138.1	4,138.7	4,140.0
2002	4,141.4	4,142.4	4,143.1	4,143.3	4,142.8	4,141.8	4,140.4	4,139.1	4,138.4	4,138.2	4,138.7	4,139.5
2003	4,141.1	4,142.2	4,143.0	4,143.0	4,142.7	4,141.5	4,140.2	4,138.9	4,138.5	4,138.3	4,138.8	4,139.9
2004	4,141.0	4,142.3	4,143.1	4,143.3	4,143.0	4,142.0	4,140.7	4,139.4	4,138.6	4,138.4	4,138.8	4,139.8
2005	4,140.6	4,141.3	4,142.1	4,142.4	4,142.9	4,142.0	4,140.7	4,139.1	4,138.2	4,138.1	4,139.1	4,140.3
2006	4,141.4	4,142.1	4,142.8	4,143.3	4,142.9	4,142.0	4,141.0	4,139.8	4,139.0	4,139.0	4,139.8	4,140.8
2007	4,141.5	4,142.7	4,143.1	4,143.3	4,143.1	4,142.1	4,140.9	4,139.6	4,138.9	4,139.0	4,139.6	4,140.5
2008	4,141.5	4,142.3	4,143.1	4,143.3	4,143.0	4,142.2	4,140.7	4,139.6	4,138.8	4,138.8	4,139.6	4,140.3
2009	4,141.5	4,142.3	4,143.1	4,143.1	4,143.0	4,142.4	4,141.0	4,139.7	4,138.8	4,138.7	4,139.1	4,139.7
2010	4,140.8	4,141.7	4,142.3	4,142.7	4,142.5	4,141.8	4,140.7	4,139.4	4,138.9	4,139.0	4,139.7	4,140.7
2011	4,142.0	4,142.4	4,142.8	4,143.2	4,142.9	4,142.1	4,141.2	4,140.1	4,139.2			

Based on the KBPM output using POR data, UKL surface elevations from the end of March through the end of May are at or above 4,142.0 ft (1,262.5 m) in 30 of 31 years. Only model year (1992) has water levels from the end of March through the end of May below 4,142.0 ft (1,262.5 m; Table 8.1). This equates to a probability slightly less than 5 percent, or slightly less than a 5 percent chance of lake surface elevations being at that elevation at the end of March.

Table 8.2 UKL end-of-month elevations in ft, February through June, at the 5 to 50 percent probability levels based on KBPM modeling of the proposed action using POR data (USBR 2012, Table 7-2).

Probability (Percent)	February	March	April	May	June
5	4,141.2 (1,262.2 m)	4,142.2 (1,262.5 m)	4,142.5 (1,262.6 m)	4,142.3 (1,262.6 m)	4,141.4 (1,262.3 m)
10	4,141.6 (1,262.4 m)	4,142.4 (1,262.6 m)	4,142.6 (1,262.7 m)	4,142.5 (1,262.6 m)	4,141.5 (1,262.3 m)
15	4,141.7 (1,262.4 m)	4,142.6 (1,262.7 m)	4,142.8 (1,262.7 m)	4,142.7 (1,262.7 m)	4,141.7 (1,262.4 m)
20	4,142.0 (1,262.5 m)	4,142.8 (1,262.7 m)	4,143.0 (1,262.8 m)	4,142.7 (1,262.7 m)	4,141.8 (1,262.4 m)
25	4,142.0 (1,262.5 m)	4,142.8 (1,262.7 m)	4,143.1 (1,262.8 m)	4,142.8 (1,262.7 m)	4,141.9 (1,262.5 m)
30	4,142.0 (1,262.5 m)	4,142.8 (1,262.7 m)	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.0 (1,262.5 m)
35	4,142.1 (1,262.5 m)	4,142.8 (1,262.7 m)	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.0 (1,262.5 m)
40	4,142.2 (1,262.5 m)	4,142.8 (1,262.7 m)	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.1 (1,262.5 m)
45	4,142.3 (1,262.6 m)	4,142.8 (1,262.7 m)	4,143.3 (1,262.9 m)	4,143.0 (1,262.8 m)	4,142.1 (1,262.5 m)
50	4,142.3 (1,262.6 m)	4,142.8 (1,262.7 m)	4,143.3 (1,262.9 m)	4,143.0 (1,262.8 m)	4,142.1 (1,262.5 m)

Based on the modeled proposed action, there is a 5 percent probability that the end of March elevation will be at or below 4,142.2 ft (1,262.5 m). Because this is 1 ft (0.3 m) higher than lake levels were during the 2010 spawning season, it is likely there would not be adverse effects to spawning, or if there are effects they would likely be small, because at this elevation approximately 74 percent of composite shoreline spawning habitat is inundated at the springs to at least 1 ft (0.3 m; Table 8.2).

Data on the effects of UKL elevations to sucker spawning behavior at shoreline springs are very limited. However, in 2010, when the surface elevation in UKL was lower than 4,141.0 ft (1,262.2 m) throughout much of the spawning season, roughly 15 percent fewer adult LRS were detected at the shoreline spawning areas, and individuals spent less time at the shoreline spawning areas than in previous years when the lake was higher (S. Burdick, USGS, pers. comm. 2012). This was especially true for females, which spent on average half as much time at the spawning grounds compared to wetter years when lake elevations were higher. These data support a conclusion that a UKL elevation of 4,141.0 ft (1,262.2 m) or less by the end of March will likely adversely impact LRS spawning at the springs in UKL. Although we have data on the percent of spawning habitat available at various UKL elevations, other than the 2010 study there is no additional information regarding how lake levels affect sucker spawning behavior. However, it is important to note that lower UKL elevations caused by Project operations in the past have still supported the annual production of millions of LRS and SNS eggs and larvae at

UKL. Based on best available information, the effects of past Project operations on sucker spawning behavior have not been a limiting factor to sucker production of eggs and larvae.

There is a 5 percent probability that the end of March elevation will be at or below 4,142.2 ft (1,262.5 m), based on the modeled proposed action. Because this is 1 ft (0.3 m) higher than lake levels were during the 2010 spawning season, it is likely there would not be adverse effects to a significant portion of the LRS and SNS spawning populations because at this elevation approximately 74 percent of composite shoreline spawning habitat for the LRS and the SNS is inundated at the springs to at least 1 foot (Table 8.3).

Table 8.3 The percent area at UKL spawning sites that are inundated to at least 1 ft (0.3 m) depth between lake levels of 4141.0 ft (1,262.2 m) and 4142.5 ft (1,262.6 m; Reclamation 2012, Table 6-1).

Lake Elevation (ft)	Sucker Springs	Silver Building Spring	Ouxy Spring	Cinder Flat	Composite of Shoreline Spawning
4,142.5 (1,262.6 m)	92				90.5
4,142.0 (1,262.5 m)	77	70	61	87	73.8
4,141.5 (1,262.3 m)	63				62.0
4,141.0 (1,262.2 m)	53	48	25	73	49.8

Based on the above information, the USFWS concludes that the proposed action is likely to result in UKL elevations in March, April, and May that during most years will provide adequate depths within shoreline spawning habitat for the LRS and the SNS during their spawning season. However, when lake levels go below 4,142.2 ft (1,262.5 m), which has a 5 percent probability of occurring and occurred once out of 31 years in the model analyses, the proposed action is likely to adversely affect sucker spawning because of reduced habitat availability. At the lowest modeled elevation of 4,141.4 ft (1,262.3 m) at the end of March, composite spawning habitat is reduced to 60 percent and there is likely to be even less spawning habitat at some springs, such as at Ouxy Springs. Under this condition, spawning could be considerably reduced because adults either do not spawn or they spawn in unsuitable habitat and that results in death of embryos or pre-swim-up larvae. Although the loss of spawning habitat is unlikely to occur during the 10-year term of the proposed action, even if such a reduction occurs it is not likely to significantly preclude the likely production of millions of LRS and SNS eggs and larvae at UKL on an annual basis for the 10-year term of the proposed Project.

By letter to NMFS dated May 29, 2013, and copied to USFWS, Reclamation proposed to modify the proposed action to provide higher minimum April through June, Klamath River flows in drier years. Reclamation stated that they did not anticipate that this modification to the proposed minimum flows will result in modeled UKL elevations during the April through June period outside those that described and analyzed in Reclamation's BA because of the following factors. To ensure that the revised minimum flows do not change the modeled UKL elevations, Reclamation will either delay the start of Project irrigation deliveries from UKL or will limit discretionary diversions from the lake by an equivalent amount to the increased releases at Link River Dam to avoid adversely impacting UKL elevations and ESA-listed suckers. Furthermore, Reclamation has assessed the potential impacts to UKL and found that lake levels are expected to be slightly higher for portions of the March through June period when a delay of the start of irrigation deliveries is implemented. This would occur because the model used to develop the Proposed Action assumed that Project deliveries would begin on March 1.

Additionally, Reclamation stated they may increase Link River flows during the April through June period to reduce coho salmon parasite concentrations in the river. The magnitude and duration of the flow increase will be developed with consideration to (a) an effective dilution factor, (b) surplus EWA volume, and (c) potential effects to UKL and ESA-listed suckers. Within 24 hours of consultation with the FASTA Team, Reclamation will implement the flow increase at Link River, if appropriate based on discussions the FASTA and the Services. A deviation from the formulaic distribution of EWA could result in short term effects to UKL elevations. In the event that a deviation from the formulaic distribution of EWA is expected to result in effects to UKL elevations throughout the spring/summer period, the FASTA Team will closely coordinate with the USFWS to ensure that the deviation will not create adverse effects greater than analyzed by USFWS. The expected end of September UKL elevation should remain unchanged as no increase to EWA will occur as a result of this change in EWA distribution.

8.3.1.2 Effects of the Proposed Action to LRS and SNS Embryo and Larval Pre-swim-up Habitat at Shoreline Springs in UKL

LRS embryos and pre-swim-up larvae are expected to be present in the gravel at the shoreline springs for approximately 3 weeks following spawning and fertilization (Perkins and Scoppettone 1996). Thus, LRS eggs fertilized in late April would be in the spawning gravel in mid-May, and any eggs fertilized in late May would still be present in the gravel in mid-June. If embryos or larvae are exposed to the air they will die from desiccation, so adverse effects could result from drawing the lake down too soon in the spring, exposing embryos or larvae. Although we do not know exactly at what elevation habitat for embryos and per-swim-up larvae becomes negatively affected, we assume those effects begin occurring when elevations in June go below 4,142.0 ft (1,262.5 m). That assumes some fertilized eggs were deposited earlier when lake levels were at near 4,143.0 feet (1,262.8 m) and at a substrate elevation of 4,142.0 ft (1,262.5 m). Exposure of embryos and pre-swim-up larvae to air is most likely to occur in June because lake levels could drop up to 1 ft (0.3 m) from May elevations (Table 8.2). That exposure is expected to occur in about 30 percent of future water years based on the POR (Table 8.5). Furthermore, the lower lake levels drop in June, the greater these effects are likely to be. However, although the loss of sucker embryos and larvae is an adverse effect to the LRS and the SNS, best available information on larval production in past years of Project operations supports a finding that implementation of proposed Project operations, which are likely to cause higher minimum lake elevations than in the past with more certainty that the minimum modeled lake elevations will not be exceeded, is likely to provide for the annual production of millions of LRS and SNS larvae in UKL. Annual production of larvae is not a limiting factor to LRS and SNS populations in UKL. Implementation of the proposed action is not likely to change that situation.

The modified proposed action, mentioned above in Sections 4 and 8.3.1.1, will not affect embryo and pre-swim-up larval habitat at the shoreline springs because UKL elevations will not be altered, or would not result in an adverse effect to LRS and SNS greater than what was analyzed here.

8.3.1.3 Effects to Larval Sucker Habitat in UKL

Mobile, free-swimming larval suckers begin appearing in UKL in late-March or April and usually peak in abundance from mid-May to mid-June; by mid- to late-July they transform to age-0 juveniles (Buettner and Scoppettone 1990, Cooperman and Markle 2003). Larval sucker habitat in UKL, especially for the SNS, is generally shallow, nearshore areas, particularly with emergent vegetation (USFWS 2008). This type of vegetation likely provides larval suckers protection from predators (Markle and Dunsmoor 2007), possibly more diverse food resources (Cooperman and Markle 2004), protection from turbulence during storm events (Klamath Tribes 1996), and hydraulic roughness that could reduce the numbers of larvae transported out of the lake by currents (Markle et al. 2009).

Although large emergent wetlands occur at several locations around UKL (e.g., Hanks Marsh, Shoalwater Bay, Upper Klamath NWR, Wood River Delta), those at the Williamson River Delta are particularly important to suckers because they are adjacent to the major source of larvae emigrating from spawning areas in the Williamson and Sprague Rivers (Dunsmoor et al. 2000). This area consistently has the highest density of larvae in UKL during late spring surveys (Terwilliger et al. 2004).

As UKL levels decrease through the summer, so does the area of inundated emergent vegetation, as exemplified by potential vegetation at the Williamson River Delta, so that at an elevation of 4,139.0 ft (1,261.6 m) almost no emergent wetland is inundated (Table 8.4). Thus, UKL elevation influences larval suckers' access to and use of nursery habitat (Dunsmoor et al. 2000, Terwilliger 2006, Markle and Dunsmoor 2007). As the area of inundated emergent vegetation declines, it is likely to reduce larval survival by exposing larvae to predators or reduced food availability, or by exposing larvae to lake currents that could carry them to the outlet of the lake where they could be entrained (USFWS 2008).

Table 8.4 Potential emergent wetland habitat at the Williamson River Delta under different UKL elevations, based on data in Elseroad (2004) and a GIS analysis of topographic data, and assuming no inundation of emergent vegetation occurs below 4139.0 ft (1,261.6 m).

UKL Elevation (ft)	Tulana Emergent Wetland Area (ac)	Goose Bay Emergent Wetland Area (ac)	Total Williamson River Delta Emergent Wetland Area (ac)
4,143.0 **(1,262.8 m)**	1,080 (437 ha)	1,560 (631 ha)	2,640 (1,069 ha)
4,142.0 **(1,262.5 m)**	850 (344 ha)	1,390 (563 ha)	2,240 (907 ha)
4,141.0 **(1,262.2 m)**	580 (265 ha)	1,080 (437 ha)	1,660 (672 ha)
4,140.0 **(1,261.9 m)**	290 (118 ha)	550 (223 ha)	870 (352 ha)
4,139.0 **(1,261.6 m)**	0	0	0

At an elevation of 4,141.0 ft (1,261.9 m), approximately 1,600 ac (648 ha) of the potential emergent vegetation habitat is available at the Williamson River Delta (Table 8.4). UKL surface elevations at or above 4,141.0 ft (1,261.9 m) by the end of June occurred in one out of the 31 modeled years (year 1992; Table 8.1). By the end of July, lake levels drop another foot from June levels (Table 8.5). The amount of emergent habitat available at the Williamson River Delta in UKL declines from 2,640 ac (1,068 ha) at an elevation of 4,143.0 ft (1,262.8 m) to 870 ac (352 ha) at an elevation of 4,140.0 ft (1,261.9 m; Table 8.4). At that elevation, any larvae not present in the wetlands could be more vulnerable to entrainment at the outlet of the lake, predation, and starvation. This would primarily affect SNS larvae because they are more dependent on wetlands than LRS larvae (Terwilliger 2006; Simon et al. 2010, 2011). At that elevation substantial larval mortality is likely because of the significant reductions in habitat that would occur. However, elevations below 4,140.0 ft (1,261.9 m) at the end of July occurred in only one year out of 31 modeled years (year 1992).

Table 8.5 UKL end-of-month elevations (in ft), April through July, at the 5 to 50 percent probability levels based on KBPM modeling of the proposed action using POR data (Reclamation 2012, Table 7-2).

Probability (Percent)	April	May	June	July
5	4,142.5 (1,262.6 m)	4,142.3 (1,262.6 m)	4,141.4 (1,262.3 m)	4,140.1 (1,261.9 m)
10	4,142.6 (1,262.7 m)	4,142.5 (1,262.6 m)	4,141.5 (1,262.3 m)	4,140.4 (1,262.0 m)
15	4,142.8 (1,262.7 m)	4,142.7 (1,262.7 m)	4,141.7 (1,262.4 m)	4,140.5 (1,262.0 m)
20	4,143.0 (1,262.8 m)	4,142.7 (1,262.7 m)	4,141.8 (1,262.4 m)	4,140.5 (1,262.0 m)
25	4,143.1 (1,262.8 m)	4,142.8 (1,262.7 m)	4,141.9 (1,262.5 m)	4,140.7 (1,262.1 m)
30	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.0 (1,262.5 m)	4,140.7 (1,262.1 m)
35	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.0 (1,262.5 m)	4,140.8 (1,262.1 m)
40	4,143.2 (1,262.8 m)	4,142.9 (1,262.8 m)	4,142.1 (1,262.5 m)	4,140.9 (1,262.1 m)
45	4,143.3 (1,262.9 m)	4,143.0 (1,262.8 m)	4,142.1 (1,262.5 m)	4,140.9 (1,262.1 m)
50	4,143.3 (1,262.9 m)	4,143.0 (1,262.8 m)	4,142.1 (1,262.5 m)	4,140.9 (1,262.1 m)

Based on the analysis presented above, the USFWS concludes that, as proposed, Project operations in most years are likely to adequately provide for inundation of emergent vegetation that is very important as larval sucker habitat during the April-July period. During those years the conservation needs of the LRS and SNS populations in UKL are likely to be met. However, when lake levels go below 4,140.0 ft (1,261.9 m) at the end of July, substantial reductions of larval habitat are likely to occur and are likely to reduce larval productivity or survival. However, such events are likely to be rare with implementation of Project operations based on modeling of the POR because such conditions occurred in only one year out of 31 modeled years. Taking into account that adult LRS and SNS are long-lived fish, such rare events are not likely to represent a significant limiting factor to persistence of LRS and SNS populations at UKL.

The modified proposed action, mentioned above in Sections 4 and 8.3.1.1, will not affect larval habitat because UKL elevations will not be altered, or would not result in an adverse effect to LRS and SNS greater than what was analyzed here.

8.3.1.4 Effects to Age-0 Juvenile Habitat in UKL

Sucker larvae transform into age-0 juveniles typically by late July, and they utilize a variety of shallow-water areas that are usually less than 3 ft deep (Buettner and Scoppettone 1990, Terwilliger 2006). As they grow, age-0 juveniles move offshore, especially LRS juveniles, which are more likely to occur offshore than SNS juveniles (Terwilliger 2006, Simon et al 2011, 2012). Habitats used by age-0 juveniles include vegetated and unvegetated areas with apparently no particular substrate size, including fine substrates such as mud (Buettner and Scoppettone 1990; Simon et al. 2000, 2009; Terwilliger 2006; Hendrixson et al. 2007a, b; Burdick et al. 2009a). However, there is evidence that the juvenile suckers use rocky substrates, such as gravel, more frequently than fine-grained substrates like mud (Terwilliger 2006; Simon et al. 2009). Access to diverse substrates might increase survival by enabling juvenile suckers to find more food or avoid predators if environmental conditions affecting the distribution of food or predators change through the summer. Additionally, water quality might vary over different substrates because of the presence or absence of currents and the DO demand by organic-rich sediments, which vary by location in UKL (Wood 2001). In general, rocky substrates in UKL are found nearshore where sediments are swept away by waves and currents (Eilers and Eilers 2005). Because of the increased circulation and lower levels of organics in these sediments, rocky areas should, in general, have higher levels of DO than those areas where mud predominates.

The habitat diversity needs for age-0 juveniles of these species are unclear, but when lake levels drop below about 4,140.0 ft (1,261.9 m) during August, vegetated wetland habitats become dewatered, and as the lake recedes below 4,138.0 ft (1,261.3 m), rocky substrates become increasingly scarce as nearshore habitats transition to mud (Simon et al. 1995, Bradbury et al. 2004, Eilers and Eilers 2005). Thus, as lake levels recede below 4,140.0 ft (1,261.9 m) and especially below 4,139.0 ft (1,261.6 m), age-0 juveniles have fewer available habitats and could be forced to move into areas where conditions (e.g., food, water quality, or predation) are less favorable, which could have negative effects on their fitness and survival. At the lowest modeled elevation at the end of August (i.e., 4,138.4 ft [1,261.4 m]), there would be almost no habitat diversity and age-0 juvenile suckers would have to use muddy substrates.

Although we do not have data showing how habitat diversity affects survival of age-0 juveniles, it is reasonable to assume if habitat becomes limiting it would affect survival. Because LRS age-0 juveniles tend to use off-shore habitats where mud substrates dominate (Terwilliger 2006; Simon et al 2010, 2011), they are less likely to be affected by low lake levels. However, because SNS juveniles are more likely to use inshore areas and a greater diversity of substrates (Terwilliger 2006; Simon et al 2010, 2011), they are more likely to be adversely affected by low lake levels. Adverse effects are most likely to occur at elevations below 4,139.0 ft (1,261.6 m) in August. Four of the 31 modeled years (13 percent) have elevations at or below 4,139.0 ft (1,261.6 m) in August (Table 8.1). Under those conditions, SNS age-0 juveniles are likely to experience low survival.

During September and October, age-0 juveniles appear to leave nearshore areas as the lake elevation is nearing its annual minimum (Buettner and Scoppettone 1990, Terwilliger 2006). It is not understood whether this seasonal movement by juveniles is related to decreasing availability of nearshore habitats resulting from declines in lake surface elevations (USFWS 2002), or other causes, such as a biological response to other natural environmental cues or changes in physiological demands during late summer (USBR 2007). In general, seasonal fish migrations are thought to maximize fitness by increasing food availability, reducing predation, or avoiding harsh environmental conditions (Brönmark et al. 2010).

Based on our review of the literature cited above, the USFWS concludes that the past pattern of age-0 juvenile sucker departure from near-shore areas in late September when the UKL surface elevation is nearing its annual minimum is not likely caused by Project operations, and instead is likely a natural behavior related to growth. However, declines in the amounts and diversity of age-0 juvenile habitats in August and early September are more likely to have adverse effects on juvenile suckers as discussed above.

The absolute minimum daily elevation, according to the KBPM outputs for the proposed action based upon the POR, is 4,137.72 ft (1,261.18 m) in early October. The BA states that Reclamation does not intend to go below 4,137.50 ft (1,261.11 m) in UKL (USBR 2012, p. 4-26). This elevation is outside of what was modeled by KBPM and, therefore, we have no way to assess its effects on the LRS and the SNS. Additionally, the effects of a 4,137.50 ft (1,261.11 m) minimum elevation in UKL were not analyzed by Reclamation. In summary, we were only able to analyze those conditions predicted by KBMP, based on the POR, so any daily UKL elevation below 4,137.72 ft (1,261.18 m) would be outside the scope of effects analyzed under this BiOp.

As discussed above, there is uncertainty regarding the effects of proposed Project operations to LRS and SNS age-0 juveniles caused by declining water levels in August and early September. However, to the degree that diverse, shallow-water habitats confer benefits to LRS and SNS age-0 juveniles, the loss of that habitat is likely to cause adverse effects. However, such events are likely to be rare with implementation of Project operations based on modeling of the POR: UKL elevation at or below 4,139.0 ft (1,261.6 m) occurred in 4 of 31 modeled years (13 percent of modeled years) during August. Taking into account that adult LRS and SNS are long-lived fish, such rare events are not likely to represent a significant limiting factor to persistence of LRS and SNS populations at UKL. However, the lack of recruitment into the adult breeding population of both species in UKL since the late 1990s is magnifying the significance of those adverse effects even though such events are likely to be infrequent.

As discussed above, there is uncertainty regarding what the effects are to LRS and SNS age-0 juveniles of the declining water levels in August and early September resulting from the proposed action. However, to the degree that diverse, shallow-water habitats confer benefits to LRS and SNS age-0 juveniles, the loss of that habitat is likely to cause adverse effects. However, such events are likely to be rare with the implementation of proposed Project operations based on modeling of the POR: UKL elevations at or below 4,139.0 ft (1,261.6 m) occurred in 4 of 31 modeled years during August. Taking into account that adult LRS and SNS are long-lived fish, such rare events are not likely to represent a significant limiting factor to persistence of LRS and SNS populations at UKL. However, the lack of recruitment into the adult breeding population of both species since the late 1990s is magnifying the significance of those adverse effects even though such events are likely to be uncommon.

Table 8.6 UKL end-of-month elevations (in feet), July through September, at the 5 to 50 percent probability levels, based on KBPM modeling of the proposed action using POR data (Reclamation 2012, Table 7-4).

Probability (Percent)	July	August	September
5	4,140.1 (1,261.9 m)	4,138.9 (1,261.5 m)	4,138.2 (1,261.3 m)
10	4,140.4 (1,262.0 m)	4,139.0 (1,261.6 m)	4,138.3 (1,261.4 m)
15	4,140.5 (1,262.0 m)	4,139.1 (1,261.6 m)	4,138.3 (1,261.4 m)
20	4,140.5 (1,262.0 m)	4,139.2 (1,261.6 m)	4,138.5 (1,261.4 m)
25	4,140.7 (1,262.1 m)	4,139.3 (1,261.7 m)	4,138.7 (1,261.5 m)
30	4,140.7 (1,262.1 m)	4,139.4 (1,261.7 m)	4,138.8 (1,261.5 m)
35	4,140.8 (1,262.1 m)	4,139.5 (1,261.7 m)	4,138.8 (1,261.5 m)
40	4,140.9 (1,262.2 m)	4,139.6 (1,261.8 m)	4,138.9 (1,261.5 m)
45	4,140.9 (1,262.2 m)	4,139.6 (1,261.8 m)	4,138.9 (1,261.5 m)
50	4,140.9 (1,262.2 m)	4,139.7 (1,261.8 m)	4,139.0 (1,261.6 m)

8.3.1.5 Effects to Habitat of Older (Age 1+) Juveniles and Adults in UKL

Radio-telemetry studies have shown that adult suckers primarily use the north end of UKL above Bare Island from June to September (Peck 2000, Reiser et al. 2001, Banish et al. 2007, Banish et al. 2009). During this period, adult suckers are found in open water areas of the lake, typically at depths of greater than 9 ft (3 m), and they tend to avoid depths less than 6 ft (2 m); in general, LRS are found farther offshore than SNS (Peck 2000, Reiser et al. 2001, Banish et al. 2009). Note that these depths were actually measured at the location of the detected fish and are not based on bathymetric maps that were inaccurate at that time.

During radio-tracking studies, neither LRS nor SNS adults were observed using depths less than 3 ft (1 m; Banish et al. 2007). In studies done in 2005 and 2006, LRS selected water depths greater than 10 ft (3 m), and SNS often selected depths greater than 6 ft (2 m; Banish et al. 2007, Banish et al. 2009). Adult suckers were mostly located at water depths greater than the mean depth available in the area of the lake where they occur, which suggests they were actively selecting for relatively deep water, but the data do not indicate where the fish are distributed through the water column. However, neither species was found at depths greater than 25 ft (8 m; Banish et al. 2007). Depths up to about 40 feet (12 m) or more occur along the east side of Eagle Ridge.

In the 2008 BiOp (USFWS 2008), one of our concerns was that low lake levels during August and September could pose a threat to adult suckers because shallow depths could reduce access into the Pelican Bay water quality refuge area. However, new bathymetric data show that water depths near Pelican Bay are deeper than previously recorded (USBR 2012). While the updated bathymetric data have not undergone a detailed quality assurance/quality control (QA/QC) review, bottom elevations in Pelican Bay have been corroborated by Reclamation (M. Neuman, USBR, pers. comm. 2013).

These new data indicate that bottom elevations at the entrance to Pelican Bay are at approximately 4,133.0 ft (1,259.7 m) to 4,134.0 ft (1,260.0 m; USBR 2012). This is several feet lower (deeper) than we assumed in 2008. During very dry conditions below the 5 percent probability for lake levels, the proposed action is likely to result in UKL surface elevations below 4,138.2 ft (1,261.3 m) by the end of September (Table 8.1 and Table 8.6). Three years out of 31 modeled years had an end-of-September elevation of 4,138.2 ft (1,261.3 m). The lowest elevation in the modeled POR that constitutes the proposed action is 4,137.7 ft (1,261.2 m). At this elevation there would be a minimum water depth of at least 4.2 ft (1.3 m) at the entrance to the bay (Table 8.7).

Table 8.7. Water depths at the entrance to Pelican Bay at various UKL elevations. The minimum bottom elevation at the entrance to the bay is approximately 4133.5 ft (1,259.9 m; Reclamation 2012, Table 7-10).

Lake Surface Elevation (ft)	Depth of Entrance to Pelican Bay (ft)
4,143.0 (1,262.8 m)	9.5 (2.9 m)
4,142.5 (1,262.6 m)	9.0 (2.7)
4,142.0 (1,262.5 m)	8.5 (2.6 m)
4,141.5 (1,262.3 m)	8.0 (2.4 m)
4,141.0 (1,262.2 m)	7.5 (2.3 m)
4,140.5 (1,262.0 m)	7.0 (2.1 m)
4,140.0 (1,261.9 m)	6.5 (1.9 m)
4,139.5 (1,261.7 m)	6.0 (1.8 m)
4,139.0 (1,261.6 m)	5.5 (1.7 m)
4,138.5 (1,261.4 m)	5.0 (1.5 m)
4,138.0 (1,261.3 m)	4.5 (1.4 m)

LRS and SNS that are unable to enter Pelican Bay could be at a higher risk from the effects of adverse water quality if conditions occur similar to those in the 1990s that led to catastrophic die-offs of adult suckers (Perkins et al. 2000b). In 1996, over 4,000 adult suckers were found dead in UKL in late August and early September and in 1997 over 2,000 adult suckers were found dead from late July to late September (Perkins et al. 2000b). In both years, ammonia levels were high and DO levels low for several weeks prior to the die-offs. For short periods, usually less than 1 day, DO concentrations ranged from 0 to 2.2 mg/L, which is within the lethal range for suckers (Perkins et al. 2000b). Additionally, at the lowest lake levels during late summer months there is an increased risk of concentrating suckers in limited areas of deeper water where disease could be more readily spread among individuals. Given that the new bathymetric data has not undergone, QA/QC review, and given the status of adult suckers, it is prudent to assume that depths at the entrance to Pelican Bay could be shallower than indicated by the new data. At the minimum proposed elevation of 4,137.7 ft (1,261.2 m), depths are likely under 4 ft (1.1 m) and pose a rare, but potentially high, risk to adult suckers. Furthermore, these low water levels make it more likely that the lake would not provide adequate spawning and rearing habitat the next spring if inflows were inadequate.

Under the proposed action, a surface elevation of 4,138.5 ft (1,261.4 m) provides approximately 13,000 ac (5,260 ha; about 46 percent) of available habitat in the portion of UKL north of Bare Island (USBR 2012, Tables 7-7 and 7-8) at depths of 6.5 ft (1.9 m) or greater without the inclusion of the reconnected Williamson River Delta. Assuming that conditions similar to those at the 5 percent probability level are experienced, such as during 1992 and 1994, it is anticipated the proposed action will result in lake elevations below 4,138.2 ft (1,261.3 m) that could provide only about 20 percent of available habitat in the northern end of UKL at depths between 6 and 9 ft (2 and 3 m) through the end of September (USBR 2012, Tables 7-6 and 7-8). Elevations below 4,138.2 ft (1,261.3 m) occurred three out of 31 years in the modeled POR.

Under proposed Project operations, there appear to be thousands of acres of potential habitat during the late summer for adult suckers, even at the lowest lake levels. However, this considers only one variable, depth, whereas radio-tracking shows that adult suckers occur seasonally in limited areas of the lake and those areas are sometimes species-specific. Areas of high seasonal use by adult suckers include Ball Bay, and the areas north of Ball Point, between Ball Bay and Fish Banks, and between Eagle Ridge and Bare Island (Reiser et al. 2001, Banish et al. 2009). SNSs, especially, show a preference for Ball Bay, whereas LRSs were frequently located off of Ball Point (Banish et al. 2009, Figure 2). Additionally, both species used the area of the lake north of Ball Bay to the mouth of Pelican Bay (Banish et al. 2009). We presume this distribution is due to selection of habitats beneficial to the LRS and the SNS for some reason(s), such as abundant food, fewer predators, and/or better water quality, in addition to adequate depth.

It is unclear how seasonal changes in lake levels affect the distribution of adult suckers, but low lake levels in very dry years could reduce use of shallow areas such as in Ball Bay. Thus, low lake levels (i.e., those below 4,138.2 ft [1,261.3 m]) in September potentially could adversely affect adult suckers by limiting their access to some preferred habitats. Recent information shows that older juvenile suckers use nearshore shallow habitats with some frequency along the western lake shore and near the Williamson River Delta (Burdick and VanderKooi 2010; Burdick 2012a, b). This suggests that low lake levels could also affect older juvenile sucker distribution if they show habitat preferences.

We assume that UKL surface elevations are less critical to adult suckers during November through February because they redistribute throughout the lake after water quality in the lake improves and as lake levels increase through the winter (Banish et al. 2007, 2009), as a result of reduced water diversions and increased inflows.

As discussed above, the USFWS concludes that the proposed Project operations are likely to provide adequate habitat for older juvenile and adult suckers during most years because there will be sufficient water depths. It is only when UKL levels are equal to or less than 4,138.2 ft (1,261.3 m) at the end of September and water depths become so shallow that there is loss of some preferred habitats that there is likely to be adverse effects to these age classes. Such lake levels occur 3 years out of 31 years in September (Table 8.1) based on the POR modeling, and thus these elevations are expected to be rare events and are not expected to limit the persistence of older juvenile and adult LRS and SNS.

8.3.1.6 Effects to UKL Water Quality

UKL has experienced serious water quality events in the past that have resulted in massive fish die-offs, including thousands of LRSs and SNSs, as well as pronounced redistribution of fish (Buettner and Scoppettone 1990; Perkins et al. 2000b; Banish et al. 2007, 2009). In UKL, water quality poses the greatest threat to all fish from July to mid-October, but especially late July and August (Wood et al. 1996, Kann 1997, Perkins et al. 2000b, Loftus 2001, Welch and Burke 2001, Wood et al 2006, Morace 2007, B. Martin, USGS, pers. comm. 2013).

One of the questions that has been raised in relation to Reclamation's management of UKL is: how do lake levels affect water quality (USFWS 2001, 2001, 2008)? A number of possible mechanisms relating lake depth to water quality have been proposed, such as effects on nutrient concentrations that drive algal productivity that subsequently affect DO and ammonia concentrations (Wood et al. 1996, Reiser et al. 2001, Morace 2007; USFWS 2002, 2008). However, most empirical analyses of water quality data taken from the lake indicate no obvious and statistically significant connection between UKL levels and water quality over the range at which the lake is usually managed (4,138 to 4,143 ft [1,261 to 1,263 m]; Wood et al. 1996, Morace 2007). However, Jassby and Kann (2010) did document a statistically significant association between chlorophyll-*a* levels in UKL and water elevations for the months of May and June.

Wood et al. (1996) concluded that there was no evidence of a relationship between any of the water quality variables considered (i.e., chlorophyll-*a*, DO, pH, total phosphorus) and lake depth based on an analysis of the seasonal distribution of data or a seasonal summary statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy AFA blooms were observed every year regardless of lake depth. Morace (2007) repeated this analysis using 11 additional years of data from UKL, and also did not detect a statistically significant relationship between lake depth and water quality. However, this does not mean that water depth has no effect on water quality, only that existing empirical data and analyses have not shown an observable, statistically significant relationship between UKL levels and water quality over the range of depths that UKL has been operated at during the 1990–2006 period. The National Research Council (2004) also did not identify a quantifiable relationship between UKL depth and extremes in DO, pH, and chlorophyll-*a*, although their analysis was considerably less robust than that of Wood et al. (1996) or Morace (2007).

In some lakes, water depth has been shown to affect water quality, but generally these lakes are at least 20 ft (6 m) deep and the change in water quality is primarily the result of stratification, which isolates bottom waters from mixing (University of Wisconsin Extension 2004, Nõges 2009). UKL is so shallow, averaging only about 6 ft (2 m) deep, that it tends to stay mixed because of the action of winds. However, during summer calm periods when the air temperature is higher, some temporary and localized stratification occurs that can lead to low DO concentrations and higher levels of ammonia in bottom waters (Kann and Welch 2005).
Lake level and water quality are difficult to analyze in UKL because the lake is a complex multi-dimensional system that exhibits considerable variability in time and space. For example, areas of the lake with high AFA biomass can experience wide swings in pH and DO over a 24-hour period due to daytime photosynthesis and nighttime respiration; however, these conditions can be localized.

The largest and longest water-quality dataset for UKL is based on samples taken twice monthly to detect long-term water quality trends. Because this dataset was developed primarily for long-term trend analysis, it lacks the spatial and temporal resolution necessary to detect effects of lake level on water quality, which would likely be relatively short term and spatially restricted. Detecting a relationship between lake levels and water quality likely requires an intensive long-term study with high spatial and temporal resolution, and thus would require financial resources beyond those available. Nevertheless, the best available information does not appear to support an effect on water quality due to UKL lake level under normal operating ranges (i.e., 4138 to 4143 ft [1,261 to 1,263 m]) of the Project.

Although the Project might not substantially affect water quality in UKL as a direct result of changes in water levels, it could affect water quality in UKL in other ways. For example, storage of winter inflows increases nutrient loading in the lake, especially sediment-bound phosphorus from tributaries during high-flow events. Diversion of water through the irrigation season exports nutrients, especially phosphorus and nitrogen contained within AFA colonies, out of the lake (ODEQ 2010). The net effects of these actions on water quality are unknown and require further study.

In conclusion, the best available information does not support a finding that proposed Project operations are likely to adversely affect UKL water quality under normal operating ranges (i.e., from 4,138.0 to 4,143.0 ft [1,261.0 to 1,263.0 m]).

8.3.1.7 Entrainment Losses of LRS and SNS from UKL

The proposed action is likely to adversely affect sucker larvae through entrainment at the A Canal, and adversely affect all life stages (other than embryos) through entrainment at the Link River Dam. The numbers of suckers at each life stage entrained by the Project are likely to vary annually depending on such factors as the flow at the A Canal and Link River Dam, numbers of adults in the spawning population, annual larval production, water quality, wind speed and direction, and other factors. For example, annual estimates of larval sucker abundance in UKL vary by several orders of magnitude (Simon et al. 2012), and this variability is likely to have a dramatic effect on entrainment rates. Additionally, estimated numbers of suckers entrained are based on only a few years of data obtained in the late 1990s by Gutermuth et al. (2000a, b). Because entrainment estimates are difficult to do and require extrapolations from short sampling times to longer periods and from small samples to larger samples, the confidence limits of the estimates are quite large.

Entrainment of larval suckers at the UKL outlet likely results from the interplay of multiple factors that are incompletely known (Markle et al. 2009). Larval suckers have limited swimming ability, are surface oriented, and therefore are vulnerable to down-lake transport by currents. Modeling using data from measurements of currents in UKL (Cheng et al. 2005) indicates that sucker larvae could be swept from spawning areas to the lake outlet in about 1 week (Reithel 2006, Markle et al. 2009). Most LRS and SNS larvae in UKL enter the lake along the eastern shoreline, either from shoreline spawning or emigration from the Williamson River. This makes them vulnerable to down-lake transport by the current that typically flows south along the eastern shore of UKL to the lake outlet (Reithel 2006, Markle et al. 2009).

Information regarding UKL's circulation suggests that larval suckers, particularly LRS larvae, could also be retained in the wind-generated gyre (current) located farther offshore (Markle et al. 2009). Under prevailing northwest winds, the circulation in UKL is a clockwise gyre that extends as far north as the shoreline between Agency Strait and Pelican Bay, and as far south as Buck Island (Wood et al. 2006). This suggests that SNS larvae could be more vulnerable to being entrained at the outlet of the lake than LRS larvae.

A Canal Entrainment Estimates

Although the A Canal is equipped with a state-of the-art fish screen meeting USFWS criteria, approximately 50 percent of those that reach the fish screen pass are likely to pass through it and are entrained into the canal system (USFWS 2008). This value is based on larval entrainment evaluations at the A Canal fish screen (Bennetts et al. 2004). The other 50 percent of larvae and all larger fish will be bypassed back to the upper Link River by a pump (typically from August through October) or discharged by a gravity-operated flume to below the dam (typically April through July). The pump bypass system uses a hidrostal pump that causes minimal injuries to fish (Marine and Gorman 2005). The outlet of the pump-bypass flume is near the west bank of the upper Link River, just downstream from the A Canal headgates and about 0.3 mi (0.5 km) upstream from the Link River Dam.

Up to 1.6 million larval suckers could be entrained into the A Canal based on estimates developed by Gutermuth et al. (2000a, b). However, that number assumes adult sucker population sizes have remained constant since the late 1990s, which is not the case, as was described above in the *Status of the Species*. Based on estimated changes in LRS and SNS population sizes (Hewitt et al. 2011), and assuming no recruitment, the total number of adult LRS and SNS in UKL has likely declined about 80 percent since 1998. Based on that, we assume numbers of larvae present and in the lake and entrained at the A Canal has also decreased because fewer adult females are now present and they would produce fewer eggs. Therefore, we assume annual larval entrainment at the A-Canal is now 20 percent of what it was in 1998 and is approximately no more than 320,000. Because this estimate is based on current LRS and SNS population sizes and further declines are likely, this number is higher than it will likely be during the 10-year term of this BiOp.

Link River Dam Entrainment Estimates

At the Link River Dam, up to 6.7 million larvae could be entrained into the spillway gates every year, based on an analysis we developed for the 2008 BO (USFWS 2008). However, that number does not take into account the 80 percent reduction in adult population sizes that have occurred since 1998, as described in section 7, *Status of the Species*. Therefore, when the 80 percent reduction in adult population size is factored in, the numbers of larval suckers annually entrained at the Link River Dam is reduced to 1.3 million. When PacifiCorp's Habitat Conservation Plan (HCP; PacifiCorp 2013) is finalized later in 2013, nearly all of the Link River flow will pass through the spillway gates of the dam, and consequently most of the take occurring there will be attributable to the Project. Therefore during most of the term of this BiOp, maximum annual larval entrainment due to Project operations is estimated to be no more than 1.3 million. Because this estimate is based on current LRS and SNS population sizes and further declines are likely, this number is higher than it will likely be during the 10-year term of this BiOp.

Additionally, we estimated that up to150,000 age-0 juveniles could be entrained at the Link River Dam every year, based on an analysis we developed for the 2008 BiOp (USFWS 2008). However as discussed above for larvae, that number does not take into account the 80 percent reduction in adult population sizes that have occurred since 1998. Therefore, when the 80 percent reduction in adult population size is factored in, the numbers of age-0 juvenile suckers annually entrained at the Link River Dam is estimated to be no more than 30,000, once PacifiCorp's HCP is in place. Because this estimate is based on current LRS and SNS population sizes and further declines are likely, this number is higher than it will likely be during the 10-year term of this BiOp.

Annual entrainment of older juvenile (including sub-adults) and adult suckers at the Link River Dam once PacifiCorp's HCP is in place is estimated to be approximately 200, based on an analysis we developed for the 2008 BiOp (USFWS 2008). Reducing this by 80 percent as was done above for larvae and juveniles, equates to an annual entrainment at the Link River Dam by the Project of fewer than 40 older juvenile and adult suckers per year.

Based on the analysis presented above, annual entrainment of suckers at the A Canal plus at the Link River Dam as a result of Project operations could be up to 1.9 million, 95 percent of which is comprised of larvae. Assessing the effects of this entrainment by the Project is complex because some entrainment would likely occur even if there was no storage or delivery of water by the Project. Also, the overall contribution of Project operations to loss of larval and juvenile suckers at the outlet of UKL is difficult to separate from other factors such as natural emigration, down-lake transport related to wind-generated currents, and transport of debilitated fish that might otherwise die from disease or predation if they remained in the lake.

We assume that most of the larvae entrained at the A Canal will likely die from adverse water quality, passing through pumps and being discharged onto agricultural fields or die when the irrigation canals are drained at the end of the season. Although we do not have specific data on survival rates, we know that some of these larvae survive because juveniles are found in the canal system when they are drained at the end of the irrigation season. Up to 1,500 age-0 juveniles are salvaged as at the end of the irrigation season and moved to permanent water bodies such as UKL where they are more likely to survive (Kyger and Wilkens 2010a).

Because of the higher summer flows in the Link River that are needed to meet Project irrigation and environmental needs, this likely results in greater entrainment of age-0 juveniles than would occur if there was no storage and delivery of water to the Project. Although fewer age-0 juveniles are entrained by the Project than larvae, loss of age-0 juveniles is more critical because of the lack of recruitment into the aging adult populations of the LRS and the SNS in UKL. The significance of this effect to UKL populations of the LRS and the SNS is likely to be magnified if the lack of recruitment into the adult population continues and the existing adult population continues to age and decline.

Entrainment rates at the A canal and Link River Dam due to Project operations are substantial although other factors are involved as discussed above. Nevertheless, we anticipate that adverse effects of entrainment to the declining adult sucker populations in UKL as a result of Project operations will be minimized through the proposed relocation of adult suckers to UKL from Lake Ewauna and the proposed controlled-propagation program, both of which are discussed below.

The modified proposed action, mentioned above Sections 4 and 8.3.1.1, will not result in entrainment rates different from those analyzed above because the modified flows at the Link River Dam are within the range considered in the above analysis.

8.3.2 Effects to LRS and SNS Populations in the Keno Reservoir and Below Keno Dam

Small numbers of the LRS and the SNS (with SNS dominating) reside in the Keno Reservoir and in the downstream hydropower reservoirs operated by PacifiCorp (Desjardins and Markle 2000, PacifiCorp 2004, Korson et al. 2008, Kyger and Wilkens 2011a, Phillips et al. 2011). Poor habitat conditions and nonnative fishes are thought to be responsible for the small numbers of LRSs and SNSs present in these reservoirs (Desjardins and Markle 2000, Piaskowski 2003; USFWS 2007c, 2008).

The proposed action has a variety of potential effects to the LRS and the SNS below the Link River Dam. Entrainment in Project facilities is one concern because Reclamation diverts water at the Lost River Diversion Channel, and North and Ady Canals. Also, there are approximately 50 smaller diversions, some of which are part of the Project; most of these lack appropriate screens. One potential effect of the Project on suckers in the Keno Reservoir is the degraded water quality, the result of nutrient-rich agricultural return flows entering the reservoir at the Straits Drain and from the Lost River Diversion Channel in winter/spring (ODEQ 2010). However, overall, the diversion of water from UKL through the Project results in a net reduction of nutrients entering Keno Reservoir from UKL (ODEQ 2010).

No known sucker spawning habitat exists in the Klamath River between the mouth of the Link River and Keno Dam (Buchanan et al. 2011). However, some sucker spawning activity has been observed in the lower Link River, upstream from the west side hydropower facility (Smith and Tinniswood 2007). It is unclear how the proposed Project operations affect upstream passage of suckers in the Link River; both high and low flows could restrict upstream passage, but intermediate flows might improve passage (Mefford and Higgs 2006). The proposed Project operations include ramping rates and minimum flows downstream from the Link River when suckers are present to reduce stranding that should eliminate nearly all of the adverse effects from ramping and low flows on affected individuals.

The proposed Project operations maintain a surface elevation in the Keno Reservoir of 4,086.5 ft (1,245.6 m), except for several days during the spring when the surface elevation is drawn down 2 ft (0.6 m) to facilitate maintenance of irrigation facilities. Stable surface elevations in the Keno Reservoir could inhibit development of additional wetland habitats and degrade the quality of existing wetlands (USFWS 2007c). Although current maximum water levels in Keno Reservoir are thought to be similar to those that occurred naturally because of a reef near Keno that controlled water levels (Weddell 2000), minimum elevations could have been lower historically due to lower flows from UKL in the summer and fall. The proposed action in Keno Reservoir is not anticipated to affect the availability of deeper habitats used by older juvenile and adult suckers.

Sampling in the Lost River Diversion Channel and near the Ady and North Canals indicates that juvenile suckers are present in low numbers near both locations during the summer (Phillips et al. 2011). Their presence near these diversions suggests that suckers could be entrained by the Lost River Diversion Channel and other Project diversions in the Keno Reservoir, but the number of suckers entrained at facilities downstream from Link River Dam is thought to progressively decrease downstream because some die and others likely remain in each reservoir, so fewer are dispersing downstream (USFWS 2007c), thus entrainment is expected to be substantially lower in the Keno Reservoir diversions than at Link River Dam.

Downstream from Keno Dam, effects of the Project on LRS and SNS are likely small in comparison to other effects because there are fewer suckers present in the reservoirs, so effects are primarily limited to changes in water quality (USFWS 2007c). The Project could also affect water quantity downstream, but this is likely minor because PacifiCorp regulates releases through the dams for hydropower production and keeps the reservoirs full, except for daily changes in reservoir elevations for hydroelectric generation.

In the Keno Reservoir the proposed action could have a variety of adverse effects to the LRS and the SNS, including entrainment into Project facilities and adverse water quality. Below Keno Dam, effects are likely limited to reduced water quality. What the effects of reduced water quality are to the LRS and the SNS is unknown and are not likely to be substantial at a population level because of the low numbers of suckers present in the reservoirs; however, any loss of suckers is adverse given the declining status of both species in the UKL recovery unit.

8.3.3 Summary of Effects of the Proposed Action to the UKL Recovery Unit

The UKL Recovery Unit is essential for the survival and recovery of the LRS and the SNS because the UKL Recovery Unit contains one of only two previously self-sustaining LRS populations, and contains the largest LRS population remaining within its range. This recovery unit contains one of only three previously self-sustaining SNS populations. For these reasons, the UKL Recovery Unit is essential for species redundancy and resiliency.

As described above, the proposed action is likely to have a variety of effects to the LRS and SNS populations in the UKL recovery unit. Some beneficial effects of the proposed action are likely to include: (1) water storage in winter in UKL that results in increases in spawning habitat and young-of-the year nursery habitat in most years, and (2) lake level variations that could help maintain marsh vegetation that requires air exposure for seedling growth.

Adverse effects to LRS and SNS populations in the UKL Recovery Unit as a result of the proposed action are likely to include: (1) decreases in age-0 juvenile and adult habitat between July and October; (2) increased risk of disease and bird predation for juveniles and adults at the lowest water levels; (4) substantial entrainment of larvae and age-0 juveniles at the A Canal and Link River Dam.

We also anticipate that adverse effects to the declining adult sucker populations in this recovery unit as a result of Project operations will be minimized through the proposed relocation of adult suckers to UKL from Lake Ewauna and the proposed controlled-propagation program, both of which are discussed below.

Proposed Project operations are compatible with the annual production of millions of LRS and SNS eggs and larvae at UKL by the sucker populations spawning in the Williamson and Sprague Rivers. Proposed Project operations are likely to cause seasonal habitat losses at UKL affecting embryo, larval, juvenile, and adult suckers, and entrainment of all life stages, and the significance of those effects are magnified by the lack of recruitment into the adult breeding populations which are aging and in decline. However, most of the adverse effects caused by proposed Project operations to habitat for sucker spawning and early life-stages are unlikely to occur during the 10-year term of the proposed Project operations because of the low frequency of the lake elevations causing those adverse effects, based on modeling of the POR.

Project-related adverse effects to age-0 juveniles are more likely to occur because those lake levels occur at a higher frequency of modeled years. Project-related habitat effects to older juveniles and adults that use deeper water are unlikely to occur during the term of the proposed action because of the low frequency of the lake elevations causing those effects based on modeling of the POR. Effects of the proposed action to water quality in UKL are unlikely, but they are more likely to occur downstream in Keno Reservoir where Project agricultural water is discharged. However, effects coming from the Project are likely to be small relative to other effects.

Project-related effects at UKL that are most likely to rise to a population-level are entrainment of juvenile suckers because of the large numbers entrained and the relative importance of juveniles in terms of likely contributing to recruitment. If there is a small level of recruitment occurring in UKL, which is likely, then any loss of young suckers by entrainment or other actions resulting from Project operations would reduce recruitment. Given the lack of documented recruitment into the adult populations of the LRS and the SNS at UKL since the late 1990s, such recruitment at UKL during the 10-year term of the proposed action is essential to the survival and the recovery of the LRS and the SNS given the important role that UKL plays in the conservation of these species. We anticipate that adverse effects to the declining adult sucker populations in UKL as a result of Project operations will be minimized through the proposed relocation of adult suckers to UKL from Lake Ewauna and the proposed controlled propagation program, both of which are discussed below.

8.3.4 Effects of the Proposed Action to the Lost River Subbasin Recovery Unit of the LRS and the SNS

As described in section 7, *Status of the Species*, of this BiOp, the Lost River Basin recovery unit for the LRS and the SNS consists of the following water bodies: (1) Clear Lake and tributaries; (2) Tule Lake; (3) Gerber Reservoir and tributaries; and (4) the Lost River (USFWS 2013). This analysis relies on the survival and recovery function assigned to each of these units to express the significance of anticipated effects of the proposed Project operations on these species. The proposed Project operations is likely to affect habitat availability for most LRS and SNS life-history stages, including larvae, age-0 juveniles, older juveniles, and adults. There is no known shoreline spawning in any of the water bodies in this recovery unit, so embryos and pre-swim-up larvae will not be affected. Additionally, because there is no emergent wetland vegetation in Clear Lake or Gerber Reservoir, the proposed action will not affect that habitat. High turbidity in Clear Lake and Gerber Reservoir likely provides cover to early sucker life-history stages similar to that provided by wetland vegetation in UKL (USFWS 2008).

8.3.5 Effects to LRSs and SNSs in Clear Lake

Clear Lake has sizeable populations of the LRS and the SNS, and may have the overall largest SNS range-wide population (<25,000; Barry et al. 2007c, 2009; Hewitt, USGS, pers. comm. 2012), but the LRS populations is likely much smaller than in UKL (10,000 in Clear Lake vs. >50,000 in UKL). Management of Clear Lake under the proposed action will continue to provide an annual minimum surface elevation of not less than 4,520.6 ft (1,377.9 m) on September 30th of each year (USBR 2012).

Under the proposed action, Reclamation plans to estimate irrigation water supplies and ensure lake levels stay above the minimum using a method similar to process that described in previous consultations (USFWS 2002, 2008). Clear Lake management consists of the following. Beginning about April 1 of each year, the April through September inflow forecast, current reservoir elevation, estimated leakage and evaporative losses, and an end-of-September minimum elevation of 4,520.6 ft (1,377.9 m) are used to predict available irrigation supplies for Clear Lake (USBR 2012). The estimated water supply is frequently updated, based on revised inflow forecasts and changes in surface elevations, through the irrigation season. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum surface elevation (USBR 2012).

8.3.5.1 Effects to Adult Sucker Spawning and Migration

Water management at Clear Lake resulting in low lake levels could adversely affect the LRS and the SNS by limiting access to Willow Creek during drought conditions (USFWS 2002, 2008). The magnitude of this impact to suckers in Clear Lake is difficult to evaluate due to the combined effects of the proposed Project operations, the high seepage and evaporative losses, lack of a long-term dataset of sucker migrations, and the sporadic nature of Willow Creek discharges. Nevertheless, adult suckers appear to enter the creek on a combined cue of creek discharge and lake elevation (Barry et al. 2009, USBR 2012). Thus, in years when lake levels are low prior to the spawning season and there are no substantial inflows, spawning migrations are relatively small in terms of sucker numbers. However, if lake levels are low early in the season but there are high inflows, as happened in 2011, lake levels can rise quickly, ensuring access into Willow Creek by the time suckers need to enter for spawning (USBR 2012). Thus, it appears that low lake levels per se are not a threat to spawning in most years, but they might be important during years of intermediate levels with intermediate flows. More studies must be completed to more fully understand this relationship. Based on best available information (Barry et al. 2009, USBR 2012), the USFWS concludes that proposed Project operations at Clear Lake over the 10-year term of this BiOp are likely to provide adequate access to spawning habitat in most years.

Taking into account that adult LRS and SNS are long-lived fish, the proposed Project operations should provide sufficient access to spawning habitat for spawning to occur at a frequency which will be sufficient to maintain a diverse age-class structure and will result in sufficient adults to maintain resiliency. Thus, proposed Project operations are not likely to represent a significant limiting factor for migration and spawning success at Clear Lake.

8.3.6 Effects to Habitat for Larvae and Age-0 Juveniles

At Clear Lake, larval and age-0 juvenile suckers likely use shallow nearshore areas just as they do in UKL, but not wetland vegetation because that is lacking in Clear Lake. Because Clear Lake is large and shallow has little substrate diversity compared to UKL, the reduction in water depth due to the combined effect of irrigation diversions and evaporation and leakage is unlikely to limit the availability of habitat for larvae or age-0 juveniles, except at the lowest water levels. Additionally, because spawning is associated with high-flow events, as mentioned above, years with substantial larval production are likely to coincide when lake elevations are relatively high due to large inflows. Consequently, substantial age-0 production is most likely to occur in wet years when the amount of habitat is substantial, and thus young-of-the-year habitat is not likely to be limiting. Therefore, proposed Project operations are not likely to limit larval and age-0 juvenile habitat.

8.3.6.1 Effects to Habitat of Older Juveniles and Adults

We assume that, when available, older juvenile (including sub-adults) and adult suckers in Clear Lake use habitats similar to suckers in UKL, such as water depths greater than 6 ft. Although the west lobe of Clear Lake has water depths greater than 20 ft (6.1m) during wet periods, much of the lake is shallow, especially the east lobe, which during droughts has a bottom elevation of about 4,520 ft (1,378 m), and is effectively unavailable to adult suckers when water levels are less than about 4,523 ft (1,379 m). Based upon the POR, there is a 20 percent probability (which equals approximately 22 years out of 110 year POR) that lake levels will reach of 4,523 ft (1,379 m) or less during the year (Table 8.8). Thus, based on the POR, 20 percent of the time lake levels during the term of this BiOp are likely to be at an elevation that is likely to cause adult suckers to avoid the west lobe of the lake or expose them to increased risk of pelican predation.

At the proposed action minimum surface elevation of 4,520.6 ft (1,377.9 m) at the end of September most of the east lobe is dry, except for the deeper pool nearest the dam into which Willow Creek flows. Based on the POR, elevations this low should be rare, because they occurred in the POR at a frequency of 5 percent (approximately 6 years out of 110 years). However, because 2 of the 8 years in the POR when this happened were in the past decade (2004 and 2010), the incidence of low lake levels is likely to be greater during the term of this BiOp than the POR suggests.

During droughts, the proposed action at Clear Lake is anticipated to adversely impact older juvenile and adult suckers by reducing habitat availability, particularly lake surface area and depth. When water depths are shallow, suckers could experience reduced body condition (i.e., be thin and have low fat reserves), have increased rates of parasitism, and be in poor health, which can lead to low productivity and perhaps increased mortality (USFWS 2008). Additionally, because in some years there is a large pelican rookery in Clear Lake, pelican predation is also likely to increase due to shallow water depths, as mentioned above.

It should be noted that low water levels in Clear Lake were likely normal prior to the construction of the Clear Lake Dam. In fact, much of the east lobe was a meadow that was used to grow hay (USFWS 2002). Reclamation’s 1905 map of Clear Lake shows that the deeper area of the east lobe was a marsh. Thus, historically, LRS and SNS in Clear Lake apparently had to cope with and adapted to varying water levels.

The minimum lake elevation being proposed for Clear Lake (i.e., 4,520.6 ft [1,377.9 m]) has not changed from minimums previously consulted on. Current monitoring data for SNS shows evidence of frequent recruitment (i.e., multiple size classes are present; Hewitt and Janney 2011). Therefore, it appears that droughts and resulting low lake levels, although are likely to have adverse effects, has not resulted in population-level effects that we have detected and thus, varying lake levels do not appear to be limiting the persistence of SNS in Clear Lake.

Current data for LRS indicates that there has been little recent recruitment in Clear Lake (Hewitt and Janney 2011), as described in section 7, *Status of the Species*. The cause of this problem is unknown. However, so called “recruitment droughts” are common among western lake suckers (Scoppettone and Vinyard 1991); although the causes are unknown and all western lake suckers are affected to some degree by water management. We don’t know exactly what is limiting LRS recruitment but Project operations cannot be ruled out because there are several potential ways that lake level management resulting in low lake levels could affect recruitment, including drought stress and increased vulnerability to pelican predation. However, low lake elevations below 4,523 ft (1,379 m) are likely to be uncommon events based upon the POR and therefore not likely to be limiting the persistence of LRS in Clear Lake.

Table 8.8 Clear Lake surface elevation probabilities in ft for the period of 1903 through 2012 (USBR 2012, Table 6-3).

Probability (Percent)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
5	4,519.8	4,519.7	4,519.8	4,519.9	4,521.5	4,522.8	4,523.0	4,522.6	4,521.2	4,520.4	4,519.5	4,519.4
10	4,521.6	4,521.8	4,522.1	4,522.4	4,523.0	4,524.3	4,525.0	4,524.8	4,523.8	4,522.8	4,521.6	4,521.4
15	4,522.0	4,522.2	4,522.9	4,523.3	4,524.3	4,525.9	4,526.0	4,525.7	4,524.7	4,523.4	4,522.1	4,521.8
20	4,523.3	4,523.4	4,524.2	4,524.6	4,525.4	4,526.6	4,527.3	4,526.8	4,525.9	4,524.7	4,523.6	4,523.0
25	4,524.1	4,524.2	4,524.9	4,525.4	4,526.0	4,527.2	4,528.5	4,527.7	4,527.2	4,526.1	4,524.9	4,524.2
30	4,524.6	4,524.9	4,526.0	4,526.3	4,526.7	4,527.7	4,528.8	4,528.8	4,527.8	4,526.5	4,525.5	4,524.8
35	4,525.8	4,526.0	4,526.5	4,527.0	4,527.4	4,528.7	4,529.6	4,529.3	4,528.7	4,527.7	4,526.6	4,526.2
40	4,526.7	4,526.7	4,526.9	4,527.5	4,528.3	4,529.8	4,530.9	4,530.6	4,529.9	4,528.8	4,527.7	4,527.1
45	4,527.2	4,527.4	4,528.0	4,528.6	4,529.6	4,530.6	4,531.5	4,531.1	4,530.3	4,529.1	4,528.2	4,527.5
50	4,528.3	4,528.3	4,528.6	4,529.2	4,530.4	4,531.3	4,532.3	4,532.0	4,531.3	4,530.4	4,529.7	4,529.0

8.3.6.2 Effects to the LRS and the SNS in Clear Lake from Water Quality

Water-quality monitoring at Clear Lake over a wide range of lake levels and years documented conditions that were adequate for sucker survival during most years (USBR1994, 2001, 2007, 2009). Thus, although low water levels could result in degraded water quality, particularly higher temperatures, and lower DO concentrations (USFWS 2008), the conditions have been within the range that is tolerated by suckers and therefore are not a limiting factor for persistence of SNS and LRS in Clear Lake.

In October 1992, the water surface elevation of Clear Lake was as low as 4,519.4 ft (1,377.5 m) before the onset of a hard winter, and no fish die-offs were observed, although suckers exhibited poor condition the following spring (USBR 1994). It is uncertain what caused the low condition factor, but it could be related to reduced water quality, crowding and competition for food, parasites, or a combination of these were responsible for impacts to suckers following winter 1992–1993. Based on this, very low lake levels in Clear Lake could pose a potential risk to listed suckers from adverse water quality. However, LRS and SNS populations have persisted under past Project management and that management is not proposed to be changed. Therefore, we do not expect low winter lake levels above 4,519.4 ft (1,377.5 m) to be a limiting factor for LRS and SNS in Clear Lake.

8.3.6.3 Effects of Entrainment and Stranding Losses of LRS and SNS at Clear Lake

The outlet at Clear Lake Dam is screened to reduce fish entrainment. Based on the screen design, Reclamation assumes no downstream losses of fish greater than about 1.4 in (35 mm) total length (USBR 2012). However, approach velocities have not been measured under a range of flows and lake levels, so they could at times exceed the screen's design criteria and result in impingement of suckers. Because the screen at this dam does not have sweeping flows to help fish move past the screen to a bypass, impingement could be occurring at higher flow velocities.

Suckers at Clear Lake Dam smaller than about 1.4 in (35 mm) total length are likely to be entrained through the fish screen because of the close proximity of the dam to the Willow Creek outlet, and the overlap between the seasonal timing of larval sucker emigration from the creek and irrigation deliveries in May and June (USBR 2012). Entrainment of older juvenile and adult suckers at the dam is prevented by the fish screen, and impingement of large suckers is unlikely because large fish can swim fast. Although the effects of entrainment has not been assessed at Clear Lake, the fact that there has been frequent recruitment of SNS, suggests it is unlikely that entrainment is a significant limiting factor to the persistence of the SNS. We assume that larval LRS are likely to be equally vulnerable to entrainment as SNS. Therefore, the lack of recent recruitment by LRS in Clear Lake is unlikely due to entrainment.

During droughts, the risk of stranding of juvenile suckers is increased at Clear Lake. For example, in 2009, the pool of water near the dam became disconnected from the east lobe of Clear Lake in July when the lake reached a surface elevation of about 4,522.0 ft (1,378.3 m) and 48 juvenile suckers were captured in the forebay of the dam and moved to the west lobe of Clear Lake (USBR 2012). The pool nearest the dam is the only known area at Clear Lake that poses a stranding risk. However, it is possible that other unidentified areas exist where stranding could occur, especially in the west lobe. The forebay area is likely unique because the greater depths there likely attract suckers as water levels recede. However, given the low numbers of juvenile suckers salvaged in 2009, it is not likely that the level of adverse effects from stranding in the forebay represents a significant limiting factor to the persistence of LRS and SNS in Clear Lake.

8.3.6.4 Summary of Effects to LRS and SNS in Clear Lake

Based on the analysis presented above, the effect of the proposed action to suckers in Clear Lake likely includes: (1) reduction of adult rearing habitat and resulting increased risk of pelican predation, reduced productivity, and increased parasitism occurring during a prolonged drought; (2) entrainment of sucker larvae at the dam; and (3) stranding of juveniles at low lake levels. The most substantial adverse effect is likely to be the loss of adult habitat during droughts because that could lead to a reduction in their condition and consequently reduced productivity and perhaps reduce egg production or survival. The lack of recent LRS recruitment in Clear Lake is troubling and low lake elevations could adversely affect productivity of adult LRS. However, lake elevations below 4,523.0 ft (1,378.6 m) are rare events based upon the POR and therefore not likely to be limiting the persistence of LRS in Clear Lake.

8.3.7 Effects to the SNS in Gerber Reservoir

Only SNS, not LRS, occur in Gerber Reservoir and there is evidence that have intercrossed to some degree with the Klamath largescale sucker (USFWS 2008). The proposed action at Gerber Reservoir, which is unchanged from past operations identified in pervious USFWS BiOps, is designed to ensure that the surface elevation is at or above 4,798.1 ft (1,462.5 m) on September 30 (USBR 2012, Table 4-15). Table 8.9 shows the Gerber Reservoir end-of-month elevations over the 1925-2012 POR.

Annual water supply projections are made for Gerber Reservoir in a similar way to those for Clear Lake. On approximately April 1 of each year, the current April through September inflow forecast, current reservoir elevation, estimated leakage and evaporative losses, and an end-of-September minimum elevation of 4,798.1 ft (1,462.5 m) are used to determine available irrigation supplies from Gerber Reservoir (USBR 2012). The available water supply is updated with new inflow forecasts and surface elevations as the irrigation season progresses. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum end-of-September surface elevation. The adequacy of proposed operations relative to the surface elevation of Gerber Reservoir and SNS life history requirements are discussed below.

8.3.7.1 Effects of Proposed Operations to Gerber Reservoir Adult SNS Spawning and Migration

Access to Ben Hall and Barnes Valley Creeks, which are the main Gerber Reservoir tributaries where SNS spawning occurs, requires a minimum surface elevation of about 4,805.0 ft (1,464.6 m) during the February through May spawning season (USFWS 2008). During very dry years, both Barnes Valley and Ben Hall Creeks typically have low spring flows that are unlikely to provide adequate upstream passage for spawning adults, regardless of lake elevations (USBR 2001a). During these conditions, spawning cues are also unlikely to be present. Although the

Gerber Reservoir surface elevations at the end of September have been observed below the proposed minimum elevation of 4,798.1 ft (1,462.5 m) in 5 years during the POR (1931, 1960, 1961, 1991, and 1992), surface elevations of at least 4,805.0 ft (1,464.6 m) were reached in these years the following spring by the end of March (USBR 2012, Appendix 6B).

Table 8.9 End of the month surface elevation probabilities in feet for Gerber Reservoir, 1925 through 2012. Source: USBR 2012, Table 6-4.

Probability (Percent)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
5	4,798.0	4,798.7	4,800.7	4,799.7	4,804.9	4,809.1	4,810.0	4,809.6	4,808.1	4,805.0	4,801.6	4,798.2
10	4,802.9	4,804.2	4,805.6	4,805.2	4,807.7	4,813.4	4,815.9	4,816.4	4,813.3	4,809.1	4,805.6	4,802.5
15	4,804.4	4,805.4	4,808.2	4,808.7	4,810.8	4,815.2	4,818.8	4,817.8	4,815.5	4,811.4	4,807.9	4,804.2
20	4,806.6	4,807.1	4,809.0	4,811.8	4,812.7	4,817.6	4,820.3	4,819.2	4,816.5	4,812.5	4,809.1	4,806.0
25	4,807.8	4,808.4	4,810.9	4,813.2	4,814.5	4,818.8	4,821.4	4,820.3	4,817.3	4,813.8	4,810.8	4,807.4
30	4,809.6	4,810.5	4,811.8	4,814.0	4,815.8	4,820.1	4,822.4	4,820.9	4,818.6	4,815.1	4,812.7	4,809.4
35	4,811.2	4,811.2	4,813.6	4,815.0	4,817.1	4,821.6	4,824.4	4,822.6	4,819.5	4,816.1	4,813.3	4,811.6
40	4,812.6	4,812.6	4,814.8	4,816.4	4,817.8	4,822.6	4,825.3	4,823.6	4,821.6	4,818.8	4,815.7	4,812.7
45	4,814.1	4,814.3	4,816.0	4,817.1	4,818.2	4,824.0	4,826.9	4,825.2	4,822.7	4,819.8	4,816.6	4,814.2
50	4,815.4	4,815.6	4,817.7	4,817.8	4,820.0	4,824.9	4,827.7	4,826.6	4,824.1	4,820.8	4,818.0	4,815.7

Based on surface elevations from the POR for Gerber Reservoir, the proposed action, which maintains the current lake management of a minimum surface elevation of 4,798.1 ft (1,462.5 m) at the end of September, will likely maintain access to spawning habitat during spring the following year. Therefore, the proposed action in Gerber Reservoir is likely to provide adequate access to spawning habitat and provide for the annual production of SNS larvae. Thus, annual production of larvae is not likely to be a limiting factor for SNS in Gerber Reservoir.

8.3.7.2 Effects to Gerber Reservoir Habitat for All SNS Life Stages

The effects of low water levels in Gerber Reservoir on SNS habitat use, population size, age-class distribution, recruitment, or decreased body condition are not fully understood. However, available information (Barry et al. 2007c, Leeseberg et al. 2007) indicates that the Gerber Reservoir SNS population has remained viable (i.e., shows evidence of regular recruitment and high abundance) under the current management regime (USFWS 2008). Because the proposed action is unchanged from past operations, low lake elevations resulting from Project operations are unlikely to limit the persistence of SNS in Gerber Reservoir.

8.3.7.3 Effects to SNS in Gerber Reservoir as a Result of Water Quality

Water quality monitoring in Gerber Reservoir over a wide range of lake levels and years has documented conditions that are periodically stressful, but typically adequate, for sucker survival. Stressful water quality conditions were limited to hot weather conditions that created high water temperatures (USBR 2001a, 2007, 2009; Piaskowski and Buettner 2003; Phillips and Ross 2012). Periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers (Piaskowski and Buettner 2003). However, stratification in Gerber Reservoir has been observed persisting for less than a month, and is confined to the deepest water in a small portion of the reservoir nearest the dam (Piaskowski and Buettner 2003). This low DO condition is likely more the result of climatological conditions, such as high air temperatures and low wind speeds, than lake surface elevations because shallower depths would likely increase mixing of bottom waters and this increase DO concentrations.

Blooms of blue-green algae can also reach densities in the fall and winter high enough to prompt advisories by the State of Oregon, but it is unknown if these blooms are directly or indirectly impacting SNS in this reservoir, or if Project operations affect the blooms.

The minimum proposed elevation for the end of September of 4,798.1 ft (1,462.5 m) in Gerber Reservoir will likely provide adequate water depths for protection against winter kill of SNS, which has apparently not occurred in the past during cold weather events where this elevation was maintained (USFWS 2008).

Based on the stability of the SNS population in Geber Reservoir, and the fact that proposed Project operations will be unchanged from past operations, adverse effects from water quality are not likely to limit the persistence of SNS in Gerber Reservoir.

8.3.7.4 Effects of Entrainment Losses of SNS at Gerber Reservoir

Past efforts to quantify entrainment or salvage-stranded suckers in Miller Creek downstream from Gerber Dam as a result of Project operations suggest that several hundred age-0 and older juvenile suckers are annually entrained at the dam as result of Project operations (Hamilton et al. 2003). Based on the quantities of water delivered in the past decade and the proposed action, Reclamation assumed several hundred age-0 and older juvenile suckers will be annually entrained under the proposed action (USBR 2012). Larval and age-0 juvenile suckers are also likely entrained, but this has not been studied.

The proposed action includes opening of Gerber Dam frost valves at the end of the irrigation season that, which allows for a flow of approximately 5 cfs (0.1 m^3/sec) in Miller Creek. Downstream accretions from seeps and storm runoff increase the actual instream flow within Miller Creek. This flow may still not be sufficient to allow for stream pool connectivity (USBR 2012) and consequently some suckers are likely to be stranded stream pools and die at the end of the irrigation season.

There is likely to be entrainment losses of larval, juvenile and adult suckers as a result of the proposed action at Gerber Reservoir. However, available information (Barry et al. 2009, 2007a, Leeseberg et al. 2007) indicates that the Gerber Reservoir SNS population has remained moderately large and has frequent recruitment under the current management regime, and so we anticipate this will continue under the proposed action. Thus, levels of entrainment that are likely to occur with implementation of the proposed action and the resulting adverse effects to SNS are unlikely to occur at a level that limits the persistence of SNS in Gerber Reservoir.

Summary of Effects to LRSs and SNSs in the Gerber Reservoir

Based on the analysis presented above, the USFWS concludes that most of the biological effects of the proposed action to SNS in Gerber Reservoir are likely to be compatible with the conservation needs of the SNS. Entrainment is likely to be the most significant adverse effect, but because the SNS population has remained viable with current levels of entrainment, and operations is not anticipated to change, adverse effects are unlikely to occur at a level that limits the persistence of SNS in Geber Reservoir.

8.3.8 Effects to the LRS and the SNS in Tule Lake Sump 1A

Tule Lake consists of two sumps: Sump 1A (9,000 ac [3,642 ha]) and Sump 1B (4,000 ac [1,619 ha]). There is a small population of the LRS and the SNS located in Sump 1A. Only, a few suckers have ever been documented in Sump 1B, despite the fact that there is access to Sump 1B from 1A (Freitas et al. 2007). It is unknown why suckers do not inhabit Sump 1B, but in an effort to better understand this situation, 18 radio-tagged suckers were experimentally put into Sump 1B in 2011 to assess their movements and survival. All, of these suckers returned to Sump 1A when access became available in 2012, confirming that, for unknown reasons, suckers prefer Sump 1A.

Although suckers in Sump 1A look healthy, based on observations of their condition factor (body fullness and low incidence of disease and parasites; Hodge and Buettner, 2007-2009), lack of spawning habitat probably prevents them from reproducing. These, populations appear to be maintained by emigration from elsewhere, probably UKL (USFWS 2008). Water levels in the Tule Lake sumps have been managed according to criteria set in previous BiOps (USFWS 2002 2008). The proposed action will continue to manage Tule Lake Sump 1A for a surface elevation of 4,034.6 ft (1,229.8 m) from April through September and an elevation of 4,034.0 ft (1,229.6 m) from October through March to provide habitat with areas of water depth greater than 3 ft (1 m) for older juveniles and adults (USBR 2012).

8.3.8.1 Effects to Adult LRS and SNS Spawning and Migration in Tule Lake Sump 1A

A minimum surface elevation of 4,034.6 ft (1,229.8 m) from April 1 to September 30 in Sump 1A was determined to provide sucker access to spawning areas below Anderson Rose Dam (USFWS 2002, 2008). The proposed action, which continues to manage Sump 1A for a surface elevation of 4,034.6 ft (1,229.8 m) from April through September, is not likely to adversely affect sucker access to areas below the Anderson Rose Dam due to surface elevations in the sump when conditions, such as flows, encourage spawning. However, it appears that successful reproduction is limited by a lack of suitable substrates and flows at the dam.

It is not clear to what degree Project operations are responsible for the variable flows in the Lost River because flows are affected by run-off; however, flows are regulated by Anderson Rose Dam, which is part of the Project. Thus, Project operations are in-part responsible for these variable flows and the loss of spawning substrate. Therefore, although proposed Project operations will provide elevations that support access to areas that historically were used for spawning, lack of suitable substrate due to past habitat alterations and past operational flows continues to limit the ability of LRS and SNS populations in Tule Lake to spawn unless dams are removed, flows regulated, and significant habitat restoration efforts are implemented.

8.3.8.2 Effects to LRS and SNS Larvae and Age-0 Juveniles Habitat in Tule Lake

The wetland area of Tule Lake Sump 1A near the Lost River outlet likely provides habitat for larvae and young juveniles, assuming that larval and age-0 juvenile suckers occur in Tule Lake and utilize nearshore and vegetated habitats similar to suckers in UKL. The minimum elevation of 4,034.6 ft (1,229.8 m) should provide adequate habitat for larval and juvenile LRS and SNS life stages because the proposed water levels will inundate hundreds of acres of emergent marsh habitat (USFWS 2008). Thus, the proposed action at Tule Lake is unlikely to limit larval and age-0 juvenile habitat.

8.3.8.3 Effects to Habitat for 1+ Juveniles and Adult LRS and SNS in Tule Lake

Water depth as cover for age 1+ suckers (age 1+ juveniles includes older juveniles) is limited due to the shallow depth of Tule Lake sump 1A, which are mostly less than 4 ft (1.2 m). One reason for the shallow depths is because sediment is being transported downstream in the Lost River and collects in Tule Lake which is the terminus of the Lost River (USFWS 2002, 2008a).

The source of the sediment is unknown, but likely is in part from runoff, some of which could come from lands that use Project water.

Surface elevations in Tule Lake Sump 1A of 4,034.6 ft (1,229.8 m) from April through September and 4,034.0 ft (1,229.6 m) from October through March appear to provide some areas of water depth greater than 3 ft (1 m) for older juveniles and adults; however, depths of less than 4 ft (1.2 m) likely make suckers vulnerable to pelican predation, and there is continued concern about the possibility of decreasing water depths in the future due to continued sedimentation (USFWS 2008). However, maintaining higher lake elevations in Tule Lake is not feasible because of the need to maintain certain maximum elevations to prevent flooding of surrounding areas in wetter periods and to support feasible project operations. Therefore, the proposed Project operations that are under the discretion of Reclamation are not likely to limit the persistence of the non-reproducing populations of SNS and LRS suckers in Tule Lake Sump 1A.

8.3.8.4 Effects to LRS and SNS in Tule Lake from Water Quality

The proposed action will likely contribute to the poor water quality in the sumps, as a result of the high nutrient concentrations of inflows and pesticide contamination of water reaching the sumps, as discussed in section 7, *Environmental Baseline,* of this BiOp. Poor water quality in Tule Lake may reduce the body condition and survivorship of individual suckers. Although, the physical condition of adult suckers in Sump 1A is generally good (Hodge and Buettner 2007, 2008, 2009), we assume that adverse effects of poor water quality are more likely to affect young suckers because of their higher metabolic rates. However, adverse effects to young suckers are dependent on them being present. Because LRS and SNS are not known to reproduce in the sumps because of the lack of suitable spawning habitat, young suckers are likely entering the sump from upstream areas and young suckers have been put into the sump as a result of past salvage efforts. Thus, at least small numbers of young suckers likely occur in the sump and any that are present are likely to be negatively affected by adverse water quality that is partially a result of Project operations. However, there is no evidence that these effects are limiting the persistence of the LRS and SNS in Tule Lake.

8.3.8.5 Effects of Entrainment Losses of LRS and SNS in Tule Lake

There are five federally owned unscreened diversion points from Tule Lake sumps (R Pump, R Canal, Q Canal, D Pumping Plant, N-12 Lateral Canal; USBR 2012). These diversions could pose a threat to suckers in Tule Lake Sump 1A because of entrainment. However, this risk is low because there are few young suckers present in the sump (Hodge and Buettner 2008, 2009). Adult suckers are less likely to be entrained because of their better-developed avoidance behavior and distribution in the sumps, which is mostly in offshore areas. Thus, the USFWS concludes that levels of entrainment that would likely occur as a result of the proposed action in Tule Lake are likely so small that it is not limiting the persistence of LRS and SNS in Tule Lake.

Summary of Effects to LRS and SNS Populations in Tule Lake Sump 1A

Based on the above analysis, the USFWS concludes the proposed action likely has minimal adverse effects to suckers in Tule Lake Sump 1A. The primary concern is that proposed action maintains water levels that likely make suckers vulnerable to pelican predation. However, maintenance of higher lake levels is not possible because it would increase the risk of flooding surrounding areas and the need to have some amount of water above minimum elevations to support project operations.

8.3.9 Effects to LRS and the SNS in the Lost River

8.3.9.1 Effects to Adult LRS and SNS Spawning and Migration in the Lost River

In the Lost River, SNS occur in small numbers, while LRS are present but very rare (Shively et al. 2000). Between June and October 1999, USGS made 141 collections at 36 stations using a variety of gear types, and obtained 87 SNS and one LRS (Shively et al. 2000). Most of the adult sucker observations in the Lost River are from the upper Lost River above Bonanza, Oregon (Shively et al. 2000). There are very few age 1+ juvenile or adult suckers residing in the lower Lost River below Wilson Dam (USBR 2001a, USFWS 2002). No adult suckers were captured in the USGS 1999 effort below Wilson Dam. Much of the fish habitat, including spawning habitat, in both the upper and lower Lost River is fragmented by dams and the irregular flows that affect adult sucker passage between habitats (Shively et al. 2000, USBR 2009, ODEQ 2010). Poor water quality also contributes to loss and fragmentation of habitat in the Lost River (USBR 2009). The proposed action, which will result in seasonally variable flows in the Lost River, is likely to cause both beneficial and adverse impacts by changing the amount of habitat. However, since the USFWS has determined that the LRS and the SNS in this area not necessary for recovery, the proposed Project operations in the Link River would not be considered an adverse effect on the condition of the species.

8.3.9.2 Effects to LRS and SNS Larval and Age-0 Juvenile Habitat in the Lost River

Larval and age-0 juvenile suckers are likely present in the Lost River in very low numbers because of limited spawning and rearing habitats and lack of upstream passage past dams, as well as adverse water quality in the summer. As a result of water management under the proposed Project operations during summer and fall, sucker habitat is likely increased in the Lost River by an unknown amount. However, during the rest of the year the proposed action will cause habitats to be fragmented as flows downstream of Clear Lake and Gerber Reservoir are reduced or halted and discharges in the Lost River decline. The reduction of flows in both the upper and lower Lost River caused by the proposed action is likely to cause stress to affected suckers from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (USBR 2007, 2009).

Based on this analysis, the USFWS concludes it is likely that the proposed action will contribute to adverse habitat conditions in the Lost River for age-0 suckers. However, since the USFWS has determined that the LRS and the SNS in this area not necessary for recovery, the proposed Project operations in the Link River would not be considered an adverse effect on the condition of the species.

8.3.9.3 Effects to Habitat for Older LRS and SNS Juveniles and Adults in the Lost River

Based on the report by Shively et al. (2000b), older juvenile and adult suckers, mostly SNSs, reside in impounded areas or deep pools in the Lost River, except during the spring spawning period when they migrate upstream to the Big Springs area, Miller Creek, or above Malone Dam (USBR 2001a, Sutton and Morris 2005).

Adult sucker habitat is fragmented within the Lost River because of dams and historic channelization that created zone of poor habitat (USFWS 2008, USBR 2009). As with earlier life stages, seasonal flow diversions under the proposed action, particularly flow reduction at the end of the irrigation season in the Lost River, will have negative impacts on suckers in the Lost River. Increased crowding of adult suckers into remaining available habitat at either the impoundments or deep pools following reduced flows at the end of the irrigation season adversely impact adult suckers in the Lost River. Inflows from groundwater and local runoff during weather events in the fall and winter periodically likely lessen the impacts of reduced habitat during the fall and winter months by reconnecting isolated areas of habitat (i.e., reservoirs and deep pools).

Based on this analysis, the USFWS concludes it is likely that the proposed action will contribute to adverse habitat conditions in the Lost River for older juveniles and adult suckers. However, since the USFWS has determined that the LRS and the SNS in this area not necessary for recovery, the proposed Project operations in the Link River would not be considered an adverse effect on the condition of the species.

8.3.9.4 Effects to LRS and SNS from Water Quality in the Lost River

Agricultural runoff and drain water that enter the Lost River are likely to contain nutrients, organics, pesticides, and sediment; these are likely to degrade sucker habitat through deteriorating water quality (USFWS 2008, USBR 2009, ODEQ 2010). The effects of this water on suckers would most likely be due to low DO concentrations, resulting from the nocturnal respiration or decay of organic matter, as well as ammonia which is a byproduct of decomposition (USFWS 2008). Pesticides are also likely present, at least in low or trace concentrations in agricultural runoff and drain water, and have been detected in the lower Lost River (Cameron 2008).

Adverse effects to LRS and SNS from Project runoff and drainage are most likely to occur in the middle and lower Lost River because water quality in the river is worse in the downstream areas (USBR 2009, ODEQ 2010). Sucker habitats in the lower river are downstream from large areas of agriculture, including much of the Project-service area. Because water quality conditions in the Lost River are due to both Project and non-Project effects, it is difficult to determine what effects are due solely to the Project. However, periods of adverse water quality, regardless of the source in the Lost River, are likely to negatively impact suckers. However, since the USFWS has determined that the LRS and the SNS in this area not necessary for recovery, the proposed Project operations in the Link River would not be considered an adverse effect on the condition of the species.

8.3.9.5 Effects of Entrainment Losses in the Lost River

Reclamation documented 130 diversions in the Lost River area; most are small pumped diversions (USBR 2001b). We assume some of these diversions use Project water, and, therefore, are part of the Project. Unscreened Project diversions in the Lost River pose an unquantified threat to suckers, but this risk is likely small because of the low numbers of suckers in the Lost River, especially young suckers that are most vulnerable to entrainment. Based on this, the proposed action will likely contribute to entrainment of suckers in the Lost River, but the effect will be small because of the low numbers of suckers present. However, since the USFWS has determined that the LRS and the SNS in this area not necessary for recovery, the proposed Project operations in the Link River would not be considered an adverse effect on the condition of the species.

8.3.10 Summary of Effects of the Proposed Action to LRS and SNS in the Lost River Subbasin Recovery Unit

The Lost River Recovery Unit is essential for the survival and recovery of the LRS and SNS because it contains one of only two self-supporting LRS populations, and contains the largest SNS population, and represents two of only three self-supporting SNS populations. This unit provides resiliency and redundancy, two factors that are essential to all populations, but especially those that are imperiled.

As described above, the proposed action is likely to have a variety of to the LRS and SNS populations in the Lost River subbasin recovery unit. Some beneficial effects of the proposed action are likely to include: (1) water storage in Clear Lake and Gerber Reservoir will provide habitat for LRS and SNS in most years; and (2) any increase in flows in the Lost River during the irrigation season will provide additional habitat.

Some compensatory elements of the proposed actions that will likely minimize adverse effects including: (1) minimum elevations in Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A will minimize adverse effects of low lake levels; (2) the Clear Lake Dam fish screen will likely reduce entrainment of juvenile and adult suckers; and (3) the 5 cfs (0.1 m^3/sec) flow below Gerber Dam during the non-irrigation season is likely to reduce mortality due to flow reductions at the end of the irrigations season.

Adverse effects of the proposed action on LRS and SNS in the Lost River Subbasin Recovery Unit are likely to include: (1) decreased habitat in Clear Lake and Gerber Reservoir in some years; (2) lower water levels in Clear Lake during droughts will likely increase risk of pelican predation and likely decrease body condition and productivity; (3) flow reduction/stoppage at the Clear Lake and Gerber Reservoir Dams at the end of the irrigation season will eliminate or reduce habitat downstream; (4) entrainment of suckers will likely occur at Clear Lake Dam and Gerber Dam; (5) agricultural return flows from the Project are likely to reduce water quality in the Lost River and Tule Lake.

Based on the best available information analyzed above, the USFWS concludes that adverse effects from the proposed action to the LRS and SNS in Lost River Basin are likely to occur as a result of habitat losses, poor water quality, entrainment, and increased vulnerability to pelican predation. These effects are unlikely to limit the persistence of LRS and SNS in the Link River Basin because the events that cause these effects are rare, occur at an insignificant level, are in areas that are not considered necessary for recovery, or are part of operations that have not limited LRS and SNS persistence in the past and are therefore not expected to limit persistence in the future.

8.4 Effects of Proposed Project Operation and Maintenance Activities

To operate the Project, Reclamation and its designees (i.e., PacifiCorp and the irrigation and drainage districts) perform annual, seasonal, and daily O&M activities. For example, gates at Gerber Dam, Clear Lake Dam, Link River Dam and fish ladder, Wilson Dam, the Lost River Diversion Channel, and A Canal are exercised by moving them up and down to be certain the gates are properly working before and after the irrigation season. The exercising of irrigation gates will likely cause avoidance by any juvenile and adult suckers in the immediate vicinity of the dam during the operations. However, a small number of suckers could be entrained through the gates and injured during exercises. The component of the proposed action that includes O&M activities of Project facilities related to dam and diversion gates is anticipated to possibly have low levels of adverse impacts to suckers, largely through harassment and therefore the USFWS concludes that this proposed activity is compatible with the conservation needs of the species. This is explained below in detail.

8.4.1 Effects of Clear Lake Dam Maintenance

Reclamation states in their BA (USBR 2012) that, typically, once each year before the start of irrigation season in March or early April, gates at Clear Lake Dam are opened to flush sediment that accumulates in front of the fish screen and dam. This activity creates a maximum release of 200 cfs (5.7 m^3/sec) and lasts for approximately 30 minutes. Periodically during the irrigation season, the fish screens at Clear Lake Dam are manually cleaned depending on the likely amount of clogging. During the cleaning, one of the two fish screen sets is always in place to prevent entrainment of juvenile and adult fishes.

Sudden opening of the Clear Lake Dam gate could entrain individual juvenile and adult suckers, but it is anticipated that most suckers will move away from the disturbance created by the open gate before the velocity is great enough to entrain them. The downstream transport of sediment into the Lost River during gate openings is temporary; most of the sediment settles in pools in the upper Lost River between Clear Lake and Malone Reservoir, and thus is only expected to result in temporary and localized reductions in water quality. Manual cleaning of the fish screens at Clear Lake Dam is anticipated to have insignificant impacts to suckers and therefore is not a limiting factor to the persistence of SNS and LRS in Clear Lake.

8.4.2 Effects of A Canal Headworks Maintenance and Canal Salvage

Gates at the A Canal are only operated and exercised with the fish screens in place (USBR 2012). If the A canal fish screens become inoperable during irrigation season, Reclamation states that it is likely that all flows will need to be temporary halted to replace or repair the screen (USBR 2012). These activities at A Canal are not anticipated to affect suckers.

At the end of the irrigation season, the A Canal gates are closed and the forebay between the trash rack and head gates is slowly dewatered to allow contained fish to escape (Taylor and Wilkens 2013). Annual fish salvage occurs within the dewatered forebay in late October or early November. During fish salvage, from 10 to 250 age-0 and older juvenile suckers are captured through seining and electrofishing (Kyger and Wilkens 2011b, 2012; Taylor and Wilkens 2013). Continued monitoring (and fish salvage when fish are observed) in the A Canal forebay during the week following initial salvage indicates very few fish remain in the forebay (Kyger and Wilkens 2011b, 2012; Taylor and Wilkens 2013). Salvaged suckers are returned to UKL.

Adverse impacts to several hundred juvenile suckers due to stress are anticipated every year during this salvage process, as well as from electroshocking, which is known to cause injuries (Snyder 2003). However, observed mortality of salvaged suckers has been low because efforts are made to ensure water quality remains high and fish are allowed to escape back into the Link River prior to salvage (Taylor and Wilkens 2013). Additionally, initial studies on electroshocking injury rates show that only a few percent of suckers suffer vertebral deformities or other adverse effects, and efforts are underway to minimize electroshocking injuries by appropriately adjusting methods (B. Phillips, USBR, pers. comm. 2013).

Stranding of suckers in canals prior to or in absence of fish salvage likely results in additional mortality (Kyger and Wilkens 2012a), and because fish are crowded before and during salvage and thus stressed, additional undetected mortality is likely. Mortality is likely to be highest in years when sucker and other fish production is high; more fish present causes crowding stress and makes it difficult to capture all of the suckers. However, it is anticipated that the adverse effects of these operations will be minimized by salvage operations where suckers are moved to areas where they are more likely to survive such as Tule Lake.

8.4.3 Effects of Lost River Diversion Channel Maintenance

Inspection of the gates and canal banks within the Lost River Diversion Channel occurs once every 6 years (USBR 2012). Inspections require a drawdown of water within the channel and can occur at any time of the year. According to the BA (USBR 2012), a drawdown of the channel is coordinated with Reclamation fish biologists to ensure adequate water remains in pools during short periods of low water levels, and pools are monitored to prevent stress to stranded fish until flows return. When practical, to reduce impacts to suckers, Reclamation will drawdown the Lost River Diversion Channel during late fall through early winter when fewer suckers are likely present. During the drawdown of the channel, some adverse impacts to LRS and SNS are likely, including an increase in predation by gulls as suckers are concentrated in shallower water and increased stress, which if prolonged could affect survival. However, adverse effects will likely be temporary (USBR 2012). Although temporary, the losses of habitat as a result of this draw-down of the Lost River Diversion Channel will likely result in adverse impacts to LRS and SNS in the channel and therefore are contrary to the conservation needs of the species. Suckers would not be present in the Lost River Diversion Channel if they we not entrained into the headworks of the channel. The effects of entrainment on LRS and SNS were analyzed above under the analysis of entrainment in the UKL recovery unit.

8.4.4 Effects of Link River Dam Fish Ladder Maintenance

Gates to the Link River Dam fish ladder are exercised twice each year: once between January and April and again between October and December (USBR 2012). While the gates are exercised, the fish ladder is dewatered and the entire structure inspected. Fish are salvaged from the ladder during dewatering and returned to either the Link River or UKL. These activities have a temporary adverse impact to suckers in and adjacent to the ladder. Because the effect is short-term and localized and because fish are salvaged, this activity is unlikely to result in significant adverse effects to LRS and SNS.

8.4.5 Effects of Maintenance to Other Project Canals, Laterals, and Drains

Nearly all Project canals, laterals, and drains are dewatered at the end of irrigation season, as late as November for canals in California (USBR 2012). Canals remain dewatered until the following spring (as early as late March) except for the input of localized precipitation-generated runoff. Reclamation has proposed a conservation measure for salvaging suckers at specific locations, as described in section 4.5.1 of the BA (USBR 2012), in an effort to minimize effects associated with dewatering canals. Past efforts have shown that salvage is practicable in some locations, but numbers of salvaged suckers are highly variable among years and sites (Taylor and Wilkens 2013). Some canal maintenance occurs during the irrigation season, such as removal of vegetation from trash racks at water control structures, but these temporary activities are only anticipated to cause short-term avoidance responses by suckers (USBR 2012).

Most canal, lateral, and drain maintenance occurs while canals are dewatered, and includes removal of sediment, vegetation, concrete repair, and culvert/pipe replacement (USBR 2012). Gates, valves, and equipment associated with canals and facilities are exercised before and after the irrigation season (before April and after October). In the past, these activities have typically occurred after dewatering the canals and fish salvage of Project canals. Some activities, such as culvert and pipe replacement, may temporarily increase sediment transportation. Based on the presence of suckers in some Project canals (Kyger and Wilkens 2011b, 2012), adverse impacts to suckers are anticipated as a result of seasonal canal dewatering and routine maintenance on canal infrastructure. Most impacts, such as increased sedimentation, are temporary and result in stress for fish. Other impacts include mortality through long-term stranding, such as when canals are dewatered and pools become disconnected. Fish salvage of the remaining pools following dewatering has prevented mortality losses of approximately 100 to 1,000 juvenile suckers yearly since 2008 (Kyger and Wilkens 2012b, Taylor and Wilkens 2013).

Fish salvage likely removes a fraction of the LRS and SNS that remain in canals that are dewatered at the end of the irrigation season, especially when the canals are drained late in the season and become covered by ice. Additionally, large numbers of gulls forage in the canals once water levels are low, and small suckers are likely among the prey caught by the birds. Therefore, there is likely to be substantial mortality of suckers associated with dewatering the canals. Because Reclamation proposes to relocate adult suckers from Lake Ewauna and put them into UKL where they can reproduce, and proposes to fund a controlled-propagation program, the effects of entrainment and mortality in canals will be minimized. It is also anticipated that the adverse effects of these operations will be minimized by salvage operations where suckers are moved to waters where they are likely to survive.

8.4.6 Effects of Right-of-way and Access Maintenance

Gravel is periodically added to roadbeds or boat ramps (e.g., at Clear Lake), and roadbeds are periodically graded (USBR 2012). Right-of-way and access maintenance may temporarily cause sedimentation into adjacent waterways, principally canals. The effects of sedimentation and noise from these activities are likely to have an insignificant and temporary adverse effect on individual suckers occupying adjacent waters.

8.4.7 Effects of Water Measurement Gage Maintenance

Water-measurement gages require annual maintenance to flush sediments from stilling wells, replace faulty gages, or modify/replace supporting structures (USBR 2012). Flushing the stilling wells occurs during irrigation season (April through October) and temporarily increases sedimentation downstream from the gage. The amount of sedimentation is often small and the sediment settles a short distance downstream, therefore, its effect is likely small. In some instances, when a large amount of sediment is present, the sediment is removed from the stilling well and deposited at a nearby upland site. Other activities, such as replacement or repositioning of a measurement device and associated infrastructure, could be conducted during low-flow periods or require construction of a small coffer dam.

Gages need to be replaced or repaired once every 5 to 10 years. If construction of a coffer dam is required, then fish will be salvaged from behind the dam prior to replacement of infrastructure. Replacing or repositioning a site will have short-term adverse impacts to suckers. Suckers will likely avoid the disturbance during activity, but may need to be captured and moved to a location away from the impacted area. Replacement of equipment and flushing of stilling wells will have temporary impact to suckers present in the immediate area of the gage. Most of these impacts are anticipated to cause nonlethal stress, which occurs briefly during site activity (USBR 2012). The USFWS concludes effects of disturbance and temporary sedimentation from these activities are likely to have an insignificant adverse effect on individual suckers occupying adjacent waters.

8.4.8 Summary of Effects of Proposed O&M Activities to LRS and SNS

O&M activities described above including maintenance of infrastructure associated with dams, canals, right-of-ways, and water measurement gages above are likely to have a range of adverse effects such as stranding, physical disturbances, and decreases in water quality that are most likely to be limited in magnitude and duration. The major effect of the O&N will be the result of lowering water levels in the Lost River Diversion Channel which because of its size could potentially contain hundreds of suckers. Because Reclamation proposes to relocate adult suckers from Lake Ewauna and put them into UKL where they can reproduce, and proposes to fund a controlled-propagation program, the effects of entrainment and mortality in canals will be minimized. It is also anticipated that the adverse effects of these operations will be minimized by salvage operations where suckers are moved to waters where they are likely to survive.

8.5 Effects of the Proposed Conservation Measures

As part of the proposed action, Reclamation proposes to implement three conservation measures for the LRS and the SNS (USBR 2012): (1) canal salvage; (2) controlled propagation; and (3) participation on the LRS & SNS Recovery Implementation Team. The effects of these measures on the LRS and the SNS are analyzed below.

8.5.1 Canal Salvage

Reclamation proposes to continue to salvage suckers in Project canals, consistent with the salvage efforts that have been occurring in Project canals since 2005 (USBR 2012). Reclamation's fish salvage efforts will focus on the A Canal forebay, C4, D1, and D3 Canals within the Klamath Irrigation District, and the J Canal within the Tulelake Irrigation District. Other salvage locations recommended by USFWS will be considered by Reclamation as requested. Additionally, Reclamation proposes to consider alternative methods of dewatering canals, laterals, and drains at the end of the irrigation season in an effort to reduce adverse effects to suckers and minimize the need for sucker salvage (USBR 2012).

The effects of canal salvage will minimize entrainment effects on suckers by relocating them to permanent water-bodies. The numbers of suckers salvaged annually is highly variable. For example, in 2006, 1,200 suckers were salvaged, whereas in 2009, fewer than 100 were salvaged (Kyger and Wilkens 2011, Taylor and Wilkens 2013). The ultimate fate of most salvaged suckers is unknown, but several lines of evidence suggest some survive and recruit into the adult population. For example, since 2006, 19 salvaged and PIT-tagged suckers have been subsequently relocated, mostly in the Williamson River. Additionally, beginning in November 2011, suckers salvaged in the Tule Lake area were put into an experimental pond on the Lower Klamath NWR. Sampling in that pond in 2012 showed that many of these suckers were alive, had grown, and were in good condition (J. Rasmussen, USFWS, pers. comm. 2012). Based on this, we believe that canal salvage will minimize entrainment losses, especially when it is done prior to ice cover and when suckers are put in appropriate habitats. However, salvage is not without risks, especially because much of it is done by electroshocking, which can injure fish (Snyder 2003), albeit at low rates (B. Phillips, USBR, pers. comm. 2013).

The USFWS concludes that proposed canal salvage will minimize the loss of young suckers that are entrained. Returning suckers to safe habitats will improve their survival and that is compatible with the conservation needs of the species.

8.5.2 Controlled (Captive) Propagation

Reclamation proposes to provide funding to the USFWS to support controlled propagation of the LRS and the SNS with the purpose of increasing the number of suckers reaching maturity in UKL. As discussed above in this BiOp there has not been any recruitment into the UKL adult population of the LRS and the SNS since the late 1990s. The current adult breeding population of suckers is aging and is nearing the end of their expected life span. The nearly universal disappearance of juvenile suckers from UKL beginning in August and extending into October (Simon et al. 2011) accounts for this situation. A controlled propagation effort is needed to prevent extinction until the threats causing the lack of juvenile survival are addressed.

Specifically, Reclamation proposes to contribute approximately $300,000 per year to the USFWS that would be used for capital and operating costs associated with a controlled propagation program. In Fiscal Year 2013, an additional $500,000 will be provided to the USFWS to accelerate the development of this program. Oversight of the controlled propagation program will be provided by USFWS with input from the Klamath Sucker Recovery Program, in coordination with Reclamation. Reclamation's support of the controlled propagation program would be for the term of this consultation (April 1, 2013 to March 31, 2023) and will start in fiscal year 2013.

Controlled propagation was listed as an action that was needed in the original LRS and the SNS recovery plan developed by the USFWS (USFWS 1993), and was also identified as being needed in the 3013 Revised Recovery Plan (USFWS 2013). The Revised Recovery Plan recommends the development of a controlled propagation program when sucker populations if sucker populations in UKL reach a level of 25 percent of their estimated abundance in 2001-2002. This trigger has been met as demonstrated by 2012 population data collected by USGS. Controlled propagation is an important part of listed fish recovery efforts nationwide, including several sucker species (e.g., the June sucker [*Chasmistes liorus*], razorback sucker [*Xyrauchen texanus*], and the robust redhorse sucker [*Moxostoma robustum*]).

The premise is that controlled propagation will enable fish to survive past the vulnerable early life stages with minimal risk of loss of genetic diversity. Controlled propagation is not based on hatchery production from fertilized eggs obtained from brood stock, but instead makes use of wild-collected young suckers that are raised in ponds, *in situ* in pens, or other enclosures. Rearing young suckers *in situ* or in ponds enables them to feed on natural prey and thus minimizes the risks of malnutrition and domestication resulting from dependence on artificial food.

In 2006, the USFWS experimentally raised wild-caught sucker larvae to a reasonably large size in one year using geothermally heated water. The key results of the experiment were:

- Sucker larvae were collected in substantial numbers in the lower Williamson River at night with lights or during the day by dip-netting them from shallow shoreline areas.
- Immediate larval mortality resulting from capture was low.
- Newly collected larvae fed and grew well on small-sized brine shrimp nauplii, and readily switched to razorback sucker chow when larger before moving to ponds.
- Juvenile suckers grew well in geothermally heated ponds, and were 6 to 9 in (15 to 22 cm) standard length after 1 year.

LRSs and SNSs also have been successfully reared in the lab to juvenile size using brood stock; however, the growth rates of young suckers in the lab are sometimes below that obtained using ponds, apparently because they lack a full complement of nutrients, such as vitamins or essential fatty acids. Although more work needs to be done before a fully functioning controlled propagation program for LRS and the SNS is effectively operating, the efforts conducted to date show that controlled propagation of the LRS and the SNS is feasible and could take a variety of forms, thus providing flexibility in terms of implementation and goals.

Controlled propagation projects for other sucker species, e.g., the June sucker, razorback sucker, and the robust redhorse sucker, have produced large numbers of suckers to supplement wild populations, and propagated suckers have successfully recruited into the adult spawning population (Modde et al. 2005, Grabowski and Jenkins 2009). However, some propagation efforts have resulted in poor survival of reintroduced suckers for a variety of reasons, including high predation rates and failure of fish to acclimate to *in situ* conditions (Marsh et al. 2005, Rasmussen et al. 2009), so some problems are anticipated and will need to be solved.

At this time, it is difficult to fully assess the effects of controlled propagation on suckers because it is a concept that needs to be further developed in concert with the Tribes and other members of the Recovery Implementation Team (described below). However, based on the success by the USFWS in 2006, success with other sucker species, and information that salvaged age-0 juveniles have recruited into the adult spawning population, it is reasonable to assume that within 2 years an effectively functioning controlled-propagation program for the LRS and the SNS can be implemented. Based on techniques utilized to rear June suckers we anticipate that with approximately 1 acre (0.4 ha) of ponds we will be able to rear 8,000 to 10,000, 8 in (20 cm)long suckers in two years. Such ponds will likely begin receiving sucker larvae in 2014, and therefore will produce juveniles by April 2016, at which time they will be released into UKL. We anticipate that propagated suckers will begin entering the reproductive populations beginning in 2019, which is 4 years before the term of this BiOp ends. Based on survival rates of June suckers of similar size, we anticipate survival rates will be 30 percent or more J. Rasmussen, USFWS, pers. com. 2012). Efforts to expand this program, through more ponds or net cage rearing within natural waters, will also be explored, but it is difficult to predict the area that will be brought under production or the efficacy of the net cages, since this method is novel for these species at this scale.

8.5.3 Capture of Adult Suckers in Lake Ewauna Reservoir and Relocation to UKL

Reclamation proposes to implement a program focused on the capture and relocation of adult suckers from Lake Ewauna and moving them to UKL where they can become part of a reproductively-functioning population. Those activities will be initiated in the fall of 2013. Based on previous sampling in the Keno Reservoir (Kyger and Wilkens 2012b), Reclamation has determined that there currently are approximately 1,000 adult SNS and from 200-1,000 LRS in the Lake Ewauna/Keno Reservoir. Reclamation proposes to capture and relocate most of the adult suckers over 3 years and to monitor and move additional adult suckers over the remaining 7 years of the term of this BiOp. Thus, during the first 3 years of the BiOp implementation nearly all of the adult suckers in the Lake Ewauna/Keno Reservoir could be relocated to UKL to supplement that population. The addition of adult suckers, especially SNS, is expected to minimize the effects of the proposed action to all sucker life stages because one adult female sucker is capable of producing many thousands of eggs over a life time. Depending upon the ages of the relocated suckers, these adults could also provide different age classes, although small, to the UKL populations of LRS and SNS.

8.5.4 Effects of Recovery Implementation Team Participation

The Revised Recovery Plan for the LRS and the SNS (USFWS 2013) calls for the establishment of a Recovery Implementation Team to coordinate implementation of the final plan. The Recovery Implementation Team will consist of agencies, groups, and individuals appointed by USFWS to participate in the implementation of actions identified in the final revised recovery plan to achieve recovery for the LRS and the SNS.

Reclamation intends to work with the USFWS, beginning in 2013, towards achieving the goals and objectives of the final revised recovery plan, which would include dedication of resources for that purpose (USBR 2012). Reclamation's involvement and support of the Recovery Implementation Team will greatly contribute to sucker recovery efforts. Considerable new information has been obtained regarding threats to these species and has been incorporated into the revised recovery plan, and therefore recovery implementation can be timelier and more effective than it has been in the past.

8.5.5 Summary of Effects to LRS and SNS from Proposed Conservation Measures

The proposed conservation measures are anticipated to have beneficial effects that will minimize effects of the proposed action to suckers and aid in their conservation. Proposed canal salvage is anticipated to benefit up to 1,500 age-0 juveniles by relocating them to permanent habitat. We anticipate that the proposed support of controlled propagation will, over the course of the 10 years, result in the development of an effective supplementation program. The goal of the program would be to minimize the adverse effects of the proposed action on LRS and SNS so that it is compatible with the conservation needs of the species. The capture and relocation efforts proposed will result in the augmentation of adult sucker populations in UKL where the populations are most at risk. Those benefits will accrue the first year of the proposed action. Thus, adverse impacts of the Project will be minimized until the controlled-propagation program is operational. Support of the Recovery Implementation Program will also benefit sucker recovery, but it is premature to speculate on what the benefits are likely to be.

8.6 Cumulative Effects - Lost River Sucker and Shortnose Sucker

Cumulative effects are those impacts of future State, Tribal, and private actions that are reasonably certain to occur within the area of the action, and are subject to consultation. There are no tribal lands within the action area. Future Federal actions will be subject to the consultation requirements established in section 7 of the Act, and therefore are not considered cumulative to the proposed action.

The following non-Federal activities are proposed in the action area:

1) The State of Oregon is enlarging its fish screening program in the Klamath Basin. Following completion of adjudication, diversions will require water measurement devices and fish screens. Although the screen mesh openings are large enough to allow larval suckers to pass, the screen design prevents entrainment of juvenile and adult suckers. This will result in a significant reduction in entrainment; however, we have no information at this time to identify how many screens and the location of screens over the next 10 years to quantify this benefit.
2) The Upper Klamath Conservation Action Network (UKCAN) works collaboratively to restore watershed processes through adaptive management. UKCAN takes an ecosystem approach, and the group focuses on conservation priorities that will benefit suckers, including restoration activities to improve both water quality and physical processes. As of 2013, funding comes through the National Fish and Wildlife Foundation's Upper Klamath Basin Keystone Initiative and the Oregon Watershed Enhancement Board's Klamath Special Investment Partnership. UKCAN partners

include the Klamath Basin Rangeland Trust, Klamath Watershed Partnership, The Klamath Tribes, The Nature Conservancy, Sustainable Northwest, Klamath Soil and Water Conservation District, Upper Klamath Water Users Association, and USFWS. UKCAN work focuses geographically on the UKL watershed, which includes the UKL, Williamson, Sprague, and Wood river sub-watersheds, as well as the Spencer Creek watershed. UKCAN has developed restoration priority actions at finer geographic scales and refines those priorities as new information is made available. Due to the funding processes, UKCAN is uncertain about the amount of restoration work that will occur in the future. However, given the amount of focused effort and the involvement of several key organizations in the Upper Klamath Basin, progress is expected toward the group's priorities over the next 10 years that will be measureable at some scales.

3) Now that the Lost River and Klamath River TMDL in California and Oregon is completed (ODEQ 2010), governmental and private entities contributing to the degradation of water quality in those rivers are required to develop and implement water quality management plans that reduce nutrient loading and aid in the improvement of water quality in the Klamath River, which should benefit suckers.
4) In 2013, PacifiCorp is scheduled to begin implementation of its habitat conservation plan to no longer operate the East Side and West Side turbines, resulting in a substantial reduction sucker mortality. PacifiCorp will also contribute $100,000 towards LRS and SNS recovery over the next 10 years. Although the projects that will receive these funds have not been identified yet, we anticipate they should result in additional recovery actions benefiting the suckers (PacifiCorp 2013). PacifiCorp will also contribute approximately $200,000 to The Nature Conservancy's Williamson River Delta Restoration project. From these contributions, an average of $4,000 per year ($40,000 over the Permit Term) will be used directly to implement additional projects to increase sucker habitat through riparian and wetland plantings along the Williamson River and the shoreline of UKL, and other sucker habitat enhancement projects at the Williamson River Delta Restoration project (PacifiCorp 2013). The remainder of funds will be used for supporting ongoing sucker recovery and land management actions by The Nature Conservancy for the restoration project, such as creating and maintaining wetlands that improve water quality and providing rearing habitat for larval and juvenile suckers. Activities funded by PacifiCorp are expected to directly or indirectly improve survival of listed suckers and increase the likelihood of recruitment to the adult population; however, none of these benefits can be quantified at this time because specific project details are not available.

Most of the non-Federal actions listed above will improve water quantity, water quality, and habitat in areas that support listed suckers, including UKL and its tributaries and the Keno Reservoir. Screening will reduce entrainment of suckers and improve overall survival. Habitat restoration will increase the amount and quality of areas important to complete sucker life cycles. Water quality improvement projects will work towards addressing a major factor limiting listed sucker recovery in the Upper Klamath Basin. If water quality is improved in Keno Reservoir, this area would likely support a substantial population of adult suckers and/or provide habitat to support larval and juvenile suckers that eventually will return to UKL as adults. Therefore, the effects of the proposed action, combined with future State, tribal, and private actions, will only result in beneficial cumulative effects to listed suckers over the next 10 years; however, none of the benefits can be quantified at this time because specific project details are not available.

9 LOST RIVER SUCKER AND SHORTNOSE SUCKER CRITICAL HABITAT

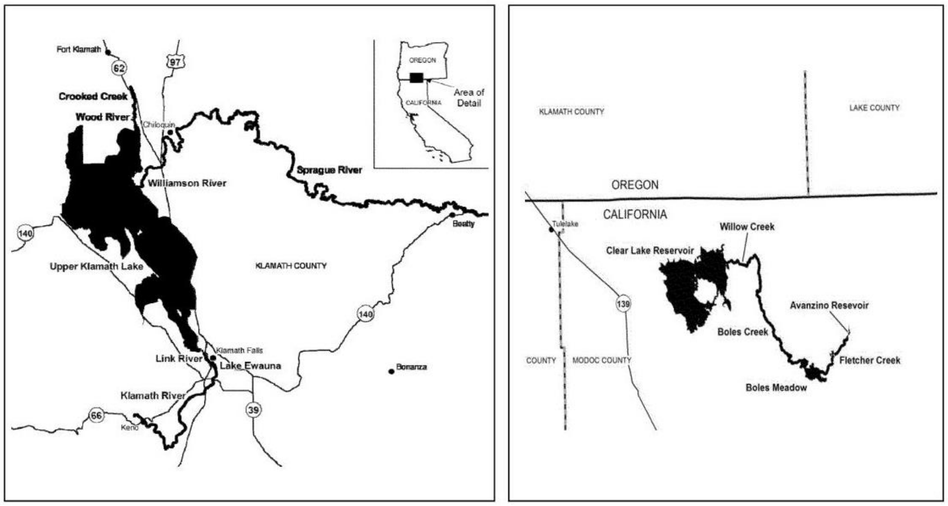
9.1 Status and Environmental Baseline of Critical Habitat

On December 11, 2012, the USFWS published a final rule designating critical habitat for the LRS and the SNS (77 FR 73740). The designation included two critical habitat units (CHUs) for each species and the units include a mix of Federal, State and private lands. The Upper Klamath Lake Critical Habitat Unit 1, situated in Klamath County, Oregon, includes UKL and Agency Lake, the Link River and upper Klamath River downstream to Keno Dam, as well as portions of the Williamson and Sprague Rivers, for a total of approximately 90,000 ac (36,422 ha) and 120 river miles. Unit 1 is the same for both species with the exception that, for the LRS, the unit extends up the Sprague River to the Beatty Gap east of Beatty (near RM 75), whereas for the SNS, Unit 1 extends up the Sprague River only as far as Braymill near RM 8.

The Lost River Basin Critical Habitat Unit 2 is situated in Klamath and Lake Counties, Oregon, and Modoc County, California. It includes Clear Lake and its main tributary, Willow Creek, for both the LRS and the SNS, and Gerber Reservoir and its main tributaries for the SNS only, for a total of approximately 33,000 ac (13,355 ha) and 88 river miles (142 km). Additionally, there are differences in the amount of upstream critical habitat in Willow Creek for the two species. For the LRS, critical habitat includes Willow Creek and its tributary, Boles Creek, upstream to Avanzino Reservoir in California. For the SNS, critical habitat extends up Willow Creek to Boles Creek and upstream past Fletcher Creek, and includes Willow, Fourmile, and Wildhorse Creeks in California, and Willow Creek to its East Fork in Oregon (Figure 9.1).

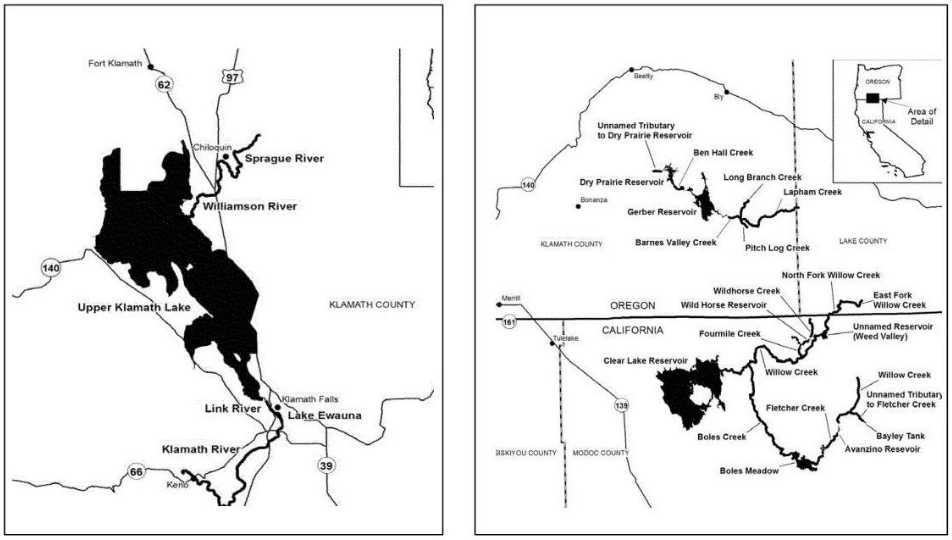
It is important to note that the action area for the proposed action encompasses the entire critical habitat designation for the LRS and the SNS.

This is the first Section 7(a)(2) consultation on potential effects to LRS and SNS critical habitat since the December 11, 2012, designation.



Lost River Sucker Critical Habitat Unit 1

Lost River Sucker Critical Habitat Unit 2



Shortnose Sucker Critical Habitat Unit 1

Shortnose Sucker Critical Habitat Unit 2

Figure 9.1 Designated CHUs for the LRS and the SNS (77 FR 73740)

In accordance with sections 3(5)(A)(i) and 4(b)(1)(A) of the Act and regulations at 50 CFR 424.12, in determining which areas within the geographical area occupied by the species at the time of listing to designate as critical habitat, we considered the physical and biological features essential to the conservation of the species which may require special management considerations or protection.

The following physical and biological features were considered essential to the conservation of each sucker species and may require special management considerations or protection:

(1) Space for individual and population growth and for normal behavior;
(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;

(3) Cover or shelter;
(4) Sites for breeding, reproduction, or rearing (or development) of offspring; and
(5) Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

The primary constituent elements (PCEs) of critical habitat are the specific elements of physical and biological features essential to the conservation of the species. Based on our current knowledge of the habitat characteristics required to sustain the species' life-history processes, the PCEs specific to self-sustaining LRS and SNS populations are:

- PCE 1—*Water.* Areas with sufficient water quantity and depth within lakes, reservoirs, streams, marshes, springs, groundwater sources, and refugial habitats with minimal physical, biological, or chemical impediments to connectivity. Water must have varied depths to accommodate each life stage: Shallow water (up to 3.28 ft [1.0 m]) for larval life stage, and deeper water (up to 14.8 ft [4.5 m]) for older life stages. The water quality characteristics should include water temperatures of less than 28.0 °Celsius (82.4 °F); pH less than 9.75; dissolved oxygen levels greater than 4.0 mg per L; low levels of microcystin; and un-ionized ammonia (less than 0.5 mg per L). Elements also include natural flow regimes that provide flows during the appropriate time of year or, if flows are controlled, minimal flow departure from a natural hydrograph.
- PCE 2—*Spawning and Rearing Habitat.* Streams and shoreline springs with gravel and cobble substrate at depths typically less than 4.3 ft (1.3 m) with adequate stream velocity to allow spawning to occur. Areas containing emergent vegetation adjacent to open water, provides habitat for rearing and facilitates growth and survival of suckers, as well as protection from predation and protection from currents and turbulence.
- PCE 3—*Food.* Areas that contain abundant forage base, including a broad array of chironomidae, crustacea, and other aquatic macroinvertebrates.

The need for special management considerations also includes the following:

- Protect and improvement of water quality by reducing sediment and nutrient loading
- Manage water bodies so that there is minimal departure from a natural hydrograph
- Maintain, improve, or reestablish instream flows to improve the quantity of water available
- Manage groundwater use to ensure it does not affect surface waters
- Address water level fluctuations in reservoirs
- Maintain appropriate depths in water quality refuge areas for access and maintaining buffers around refuge areas
- Maintain habitat in reservoirs, the timing and volume of water diverted needs to be addressed
- Improve access to spawning and rearing habitats
- Manage exotic fishes by restoring habitats for native fishes.

These are discussed in greater detail in the final critical habitat rule (77 FR 73740).

9.2 Analytical Approach and Role of Critical Habitat in LRS and SNS Recovery

This BiOp does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this BiOp relies on four components: (1) the status of critical habitat, which evaluates the range-wide condition of designated critical habitat for the LRS and the SNS in terms of primary constituent elements (PCEs), factors responsible for that condition, and the intended recovery function of the critical habitat overall, as well as the intended recovery function in general of critical habitat units; (2) the environmental baseline, which evaluates the condition of the critical habitat in the action area, factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the effects of the action, which determines direct and indirect impacts of the proposed Federal action and effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) cumulative effects, which evaluates the effects of future non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on LRS and SNS critical habitat are evaluated in the context of the range-wide condition of the critical habitat, taking into account cumulative effects to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for these two species.

The analysis in this BiOp places an emphasis on using the intended range-wide recovery function of LRS and SNS critical habitat and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the destruction or adverse modification determination.

An adverse modification analysis determines if the physical or biological features of critical habitat would remain functional to serve the intended recovery role for the species as a result of implementation of a proposed Federal action (77 FR 73740). The key factor related to the adverse modification determination is whether, with implementation of the proposed Federal action, the affected critical habitat would continue to serve its intended conservation role for the species. Activities that may destroy or adversely modify critical habitat are those that alter the physical or biological features to an extent that appreciably reduces the conservation value of critical habitat for the LRS and the SNS (77 FR 73740). The role of critical habitat is to support life-history needs of the species and provide for the conservation of the species.

Additionally, it is important to note that the hydrologic thresholds identified in the effects analysis for the LRS and the SNS also apply to the critical habitat analysis below.

9.3 Effects of Proposed Project Operations to LRS and SNS Critical Habitat

At issue are effects of proposed Project operations on 3 PCEs: (1) water; (2) spawning and rearing habitat; and (3) food. Given the nearly universal disappearance of age-0 juvenile suckers from UKL beginning in August and extending into October (Simon et al. 2011) and the lack of known recruitment into the adult breeding population since the late 1990s, it is very important that sucker critical habitat at UKL consistently provide for adequate spawning habitat for adult suckers, adequate rearing habitat for sucker embryos, larvae, and juveniles, and adequate foraging habitat (inclusive of a diverse and abundant prey base) for all sucker life stages to adequately support the conservation of these species.

At other water bodies within the range of critical habitat for these species where the status of the LRS and the SNS is stable, more variation in the quality of PCE function can occur and still adequately support the conservation of the suckers.

9.3.1 Effects to LRS and SNS Critical Habitat Unit 1

Critical habitat was designated for the LRS and the SNS in Unit 1 at UKL and along its primary tributaries, including the lower Williamson, the lower Sprague, and lower Wood Rivers (77 FR 73740). This unit also includes critical habitat designated downstream of Link River Dam at the outlet of UKL to Keno Dam (77 FR 73740).

9.3.1.1 Effects to LRS and SNS Critical Habitat in UKL and its Tributaries

9.3.1.1.1 Effects to PCE 1: Water

The proposed action is not anticipated to measurably influence water quality in UKL because water quality conditions in UKL are primarily influenced by climate, external and internal nutrient loading, and algae crashes (Morace 2007), and information is lacking showing that Project operations are likely to have substantial effects on any of these factors. Storage and delivery of water in UKL under the proposed action could potentially affect nutrient cycling in UKL, but this requires additional study. Based on best available information, discussed in section 7, *Environmental Baseline* for LRS and SNS, the USFWS finds no appreciable causal link between past and proposed Project operations and adverse or beneficial effects to nutrient cycling in UKL.

The proposed Project operations are also unlikely to have any effect on sediment or nutrient input into the lake because most of the sediment and nutrient input into the lake is occurring upstream of the lake. Nutrients are also released into the lake by internal processes called "internal loading" (e.g., diffusing from sediments and through death of AFA), but there is no documented link between internal loading and Project operations. Because Project operations store and deliver water from UKL, those activities could affect nutrient storage and export, but it is not clear what the net effect is on nutrient cycling in the lake. In fact, it is possible that the two effects balance each other. However, there is evidence that water diversions through the Project cause a net reduction in nutrients downstream of UKL (ODEQ 2010).

The proposed action will have no effect on water quality in the tributaries to UKL within LRS and SNS critical habitat because these areas are upstream of the Project, except near the confluence of the tributaries with UKL where there is influence of lake management. Therefore, water management by the Project will only affect the lower-most reaches of the Williamson and Wood Rivers that are influenced by UKL elevations. However, as stated previously, USFWS finds there are no casual links between Project operations and water quality.

9.3.1.1.2 Effects to PCE 2: Spawning and Rearing Habitat

The proposed action will have no effect on sucker critical habitat in the tributaries to UKL with respect to its capability to adequately support sucker migration and spawning habitats that are essential to the recovery of these species. All known spawning sites are upstream of the reaches of these rivers affected by UKL elevations.

Implementation of proposed Project operations over the term of this BiOp (10 years) is likely to create higher than natural surface water elevations in UKL in the spring as a result of water storage. These water levels are likely to support extensive amounts of moderate to high-quality sucker spawning, rearing, and foraging habitat that will facilitate the annual production of millions of sucker eggs, embryos, larvae, and age-0 juveniles. This aspect of proposed Project operations is likely to provide significant beneficial effects to the recovery- support function of critical habitat for the LRS and the SNS in UKL.

However, modeling of the proposed action shows that there could be years when water levels are so low that it could negatively affect the ability of spawning habitats to support the recovery function of critical habitat for the LRS and the SNS in UKL. As was discussed in section 7.10, sucker spawning and larval rearing habitat is likely to be greatly reduced only at the lowest lake levels and those elevations occurred only once in 31 modeled years, and thus they are unlikely to occur during the term of this BiOp. Similarly, adverse effects to larval rearing habitats are unlikely because the elevations at which adverse effects only occur at a frequency of one in 31 modeled years, and thus are unlikely to occur during the term of this BiOp.

In August and early September, rearing habitat for age-0 juveniles, primarily for SNS because they are more shoreline-oriented than LRS, could be reduced by the proposed action to the point where it is likely to have adverse effects. Although there is no definitive information regarding the fate of the affected age-0 juveniles that are displaced by draw-down operations during the late summer, it is reasonable to assume that their fitness and survival are likely reduced due perhaps to the lesser abundance of preferred prey species and perhaps increased exposure to predatory, introduced fishes that are abundant in UKL. Age-0 juveniles must avoid predators and have access to abundant high-quality food to grow and survive through the winter when they are less active and food is less plentiful. In most years there is unlikely to be a substantial reduction in age-0 juvenile habitat, but in about 13 percent of the years, age-0 juvenile habitat will be substantially affected. Thus, although the adverse effects to age-0 juvenile habitat are infrequent, the recovery-support function of critical habitat for the LRS and the SNS in UKL is unlikely maintained in 13 percent of years.

9.3.1.1.3 Effects to PCE 3—Food

In UKL, because of its high productivity, the proposed action is not anticipated to affect the availability of food invertebrates, especially midges, cladocerans, and copepods. Thus, the proposed action does not affect the recovery-support function of critical habitat to provide food for the LRS and the SNS in UKL. The proposed action does not affect food availability in the tributaries to UKL.

The modified proposed action, mentioned above Sections 4 and 8.3.1.1, will not affect critical habitat in UKL because UKL elevations will not be altered, or would not result in an adverse effect to LRS and SNS greater than what was analyzed here.

9.3.1.2 Effects to LRS and SNS Critical Habitat at Keno Reservoir

9.3.1.2.1 Effects to PCE 1—Water

The proposed action has much more of an effect on water quality in Keno Reservoir than to UKL because it is downstream of parts of the Project. This is discussed in detail in Section 7.10, but in general, the quality of water entering, within, and leaving the Keno Reservoir is largely due to water entering from UKL containing large amounts of organic matter with an associated high oxygen demand (Doyle and Lynch 2005; Deas and Vaughn 2006; ODEQ 2010). Because downstream flows at the Link River Dam during the summer are in part used to meet demands from Project diversions at the Lost River Diversion Channel and Ady and North Canals, the degraded water quality in the Keno Reservoir is partially due to the proposed action. Also, drain water coming from the Project containing high concentrations of nutrients degrades water quality in the vicinity of the Straits Drain at the south end of the reservoir (ODEQ 2010). Additionally, winter storm-driven run-off containing nutrients and sediments from the Lost River empties into the Lost River Diversion Channel and that is likely to contribute to stressful water quality conditions in the Keno Reservoir. Currently, because of the multiple factors affecting water quality in the Keno Reservoir, we cannot quantify how much of the degradation to water quality is caused by past Project operations and is likely to be caused by proposed Project operations, but Project operations are contributing to degraded water quality at Keno Reservoir. To the degree that the Project is contributing to this problem, those effects are limiting the ability of critical habitat in Keno Reservoir to provide sucker rearing and foraging habitats that are essential to the recovery of these species. Thus, the proposed action is likely to have some unquantifiable negative effects to the recovery-support function of critical habitat for the LRS and the SNS in Keno Reservoir.

Water-surface elevations and depths likely to occur under the proposed action at Keno Reservoir are expected to be similar to recent and historic elevations, which are mostly compatible with the life-history requirements of the suckers. However, the maintenance of constant water levels in Keno Reservoir is likely contributing to adverse water quality and degradation of marsh habitat important for young suckers.

9.3.1.2.2 Effects to PCE 2—Spawning and Rearing Habitat

Suckers have been seen spawning in the lower Link River, but it appears to be limited to a few individuals and it is not known if this is a regular occurrence. In May 2007, 10 suckers were seen showing behaviors known to be associated with spawning (Smith and Tinniswood 2007).

No other spawning habitat exists between the Link River and Keno Dam (Buchanan et al. 2011). The proposed operation of the Link River Dam for downstream water needs is not anticipated to affect spawning habitat (PCE2) in the Link River.

The ongoing management to operate for stable surface elevations in the Keno Reservoir is likely to retard development of additional wetland habitats and could degrade the quality of existing wetlands through controlled water depth and this is likely to adversely impact young suckers that use this habitat (USFWS 2007c). However, stable surface elevations do provide sucker access to the established wetland habitats for rearing during sucker early life history stages. To the degree that the Project is contributing to habitat degradation in Keno Reservoir, those effects are limiting the ability of critical habitat to provide sucker rearing and foraging habitats that are essential to the recovery of these species. Thus, the proposed action is likely to have some negative effects to the recovery-support function of critical habitat for the LRS and the SNS in Keno Reservoir.

9.3.1.2.3 Effects to PCE 3—Food

Although we are not aware of any studies on invertebrates in the Keno Reservoir, we assume that invertebrate diversity and abundance at Keno Reservoir are high and are similar to those in UKL. Additionally, flows from UKL likely bring prey species such as amphipods, cladocerans, copepods, and midges into the reservoir and the large amounts of organics that enter the reservoir from UKL could provide a substantial food base for invertebrates. For those reasons, the proposed action is not likely to reduce the recovery-support function of critical habitat to provide food for the LRS and the SNS in the Keno Reservoir.

9.3.1.3 Summary of Effects to LRS and SNS Critical Habitat Unit 1

There is no causal link to adverse effects to water quality (PCE1) in UKL; however, there is evidence that water diversions through the Project cause a net reduction in nutrients downstream of UKL, which is beneficial. However, in Keno Reservoir, there are return flows into the reservoir from agricultural diversions that are part of the proposed action, resulting in some negative effects to water quality.

Proposed Project operations result in higher lake elevations in UKL in the spring and early summer which is protective and beneficial to the spawning habitat component of PCE2 in all but one of the 31 modeled years. Rearing habitat for age-0 juvenile suckers is adversely affected in 13 percent of the modeled years of the proposed action and will have a negative impact on the critical habitat ability to provide for adequate rearing habitat as part of the intended recovery role for the species. The proposed Project does not affect food availability (PCE3) in Unit 1.

9.3.2 Effects to LRS and SNS Critical Habitat Unit 2

Critical habitat was designated for the LRS and the SNS in Unit 2 includes Clear Lake and its main tributary, Willow Creek, for both the LRS and the SNS, and Gerber Reservoir and its main tributaries for the SNS only. Additionally, there are differences in the amount of upstream critical habitat in Willow Creek for the two species. For the LRS, critical habitat includes Willow Creek and its tributary, Boles Creek, upstream to Avanzino Reservoir in California. For the SNS, critical habitat extends up Willow Creek to Boles Creek and upstream past Fletcher

Creek, and includes Willow, Fourmile, and Wildhorse Creeks in California, and Willow Creek to its East Fork in Oregon (77 FR 73740).

9.3.2.1 Effects to LRS and SNS Critical Habitat at Clear Lake and in Willow Creek

9.3.2.1.1 Effects to PCE 1—Water

At Clear Lake, the proposed action is not likely to affect water quality except at the lowest lake levels (discussed in Section 8.3.5 in more detail). However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival during most years (USBR 1994, 2001a, 2007). Although low water levels could result in degraded water quality, particularly higher temperatures, and lower DO concentrations (USFWS 2008), the conditions have been within the range that is tolerated by suckers and therefore are not a limiting factor for persistence of SNS and LRS in Clear Lake. Therefore, the USFWS finds that proposed Project operations at Clear Lake are not likely to adversely affect water quality necessary to adequately support recovery of the LRS and the SNS. Thus, the proposed action in Clear Lake is likely to provide the necessary recovery-support function of critical habitat for the LRS and the SNS for water quality.

9.3.2.1.2 Effects to PCE 2—Spawning and Rearing Habitat

Access to spawning habitat in Willow Creek, which is the only know habitat used for spawning by suckers in Clear Lake, appears to be mostly dependent on Willow Creek flows, as discussed in Section 8.3.5 thus the effects of lake levels from the proposed action on spawning habitat component of PCE2 are thought to be minimal. Taking into account that adult LRS and SNS are long-lived fish and that the proposed action is unchanged from past operations, the proposed Project operations should provide sufficient access to spawning habitat for spawning to occur at a frequency which will be sufficient to maintain a diverse age-class structure and will result in sufficient adults to maintain resiliency. Thus, proposed Project operations are not likely to represent a significant limiting factor for migration and spawning success at Clear Lake.

The proposed action is likely to provide adequate rearing habitat for all sucker life stages in Clear Lake except during droughts when both water depth and surface area contracts, therefore affecting components of PCE 2. The amount of habitat in Clear Lake is highly variable because inflows to Clear Lake are characterized by multiple low-inflow years punctuated by less frequent high inflow years. Additionally, evaporation and leakage are high because of the shallow depths and large surface area of the lake. At the lowest lake levels under the proposed action, water depths in the west lobe are so low that suckers could get stranded and would be vulnerable to pelican predation. Those conditions are likely to occur once during the proposed action because they occurred in the POR at a frequency of 5 to10 percent. The minimum proposed Clear Lake elevations will likely provide adequate protection from drought in most years, but extended drought will result in a significant reduction in lake area and depth. Thus, the proposed action is likely adversely affecting rearing habitat during droughts that are likely to occur once during the term of this BiOp.

Although there are adverse effects to this PCE, negative impacts to the recovery role of the component of critical habitat in Clear Lake are not anticipated. The minimum lake elevation being proposed for Clear Lake (i.e., 4,520.6 ft) has not changed from minimums previously consulted on. Current monitoring data for SNS shows evidence of frequent recruitment (i.e., multiple size classes are present; Hewitt and Janney 2011). Therefore, it appears that droughts and resulting low lake levels, although are likely to have adverse effects at the time they occur, has not resulted in population-level effects that we have detected and thus, varying lake levels do not appear to be limiting the persistence of SNS in Clear Lake.

Current data for LRS indicates that there has been little recent recruitment in Clear Lake (Hewitt and Janney 2011), as described in the section 7, *Status of the Species*. The cause of this problem is unknown. However, so called “recruitment droughts” are common among western lake suckers (Scoppettone and Vinyard 1991); although, the causes are unknown and all western lake suckers are affected to some degree by water management. We do not know exactly what is limiting LRS recruitment but Project operations cannot be ruled out because there are several potential ways that lake level management resulting in low lake levels could affect recruitment, including drought stress and increased vulnerability to pelican predation. However, low lake elevations below 4523 ft are likely to be uncommon events based upon the POR and therefore not likely to be limiting the persistence of LRS in Clear Lake. Therefore, adverse effects to rearing habitat from proposed Project operations are not likely limiting the conservation role of critical habitat for LRS.

9.3.2.1.3 Effects to PCE 3—Food

No specific data concerning the availability of food in Clear Lake exists; however, for the following reasons the USFWS believes this is probably not a limiting factor for the LRS and SNS that occur there. The reservoir contains a very large amount of habitat and is productive enough to maintain dense populations of zooplankton. Also, although juveniles weigh slightly less at a given size in Clear Lake than do their counterparts in UKL (Burdick and Rasmussen 2012), captured individuals do not appear to be unhealthy or of low condition. Therefore, food availability is not adversely affected by the proposed action and this PCE supports the recovery-support function of critical habitat for the LRS and the SNS in Clear Lake.

9.3.2.2 Effects to LRS and SNS Critical Habitat in Gerber Reservoir and Its Tributaries

9.3.2.2.1 Effects to PCE 1—Water

The proposed action does not affect PCE1 in the tributaries of Gerber Reservoir because Project operations do not extend to the tributaries.

Water quality monitoring in Gerber Reservoir over a wide range of lake levels and years has documented conditions that are periodically stressful, but typically adequate, for sucker survival. Stressful water quality conditions were limited to hot weather conditions that created high water temperatures (USBR 2001a, 2007, 2009; Piaskowski and Buettner 2003; Phillips and Ross 2012). Periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers (Piaskowski and Buettner 2003). However, stratification in Gerber Reservoir has been observed persisting for less than a month, and is confined to the deepest water in a small portion of the reservoir nearest the dam (Piaskowski and Buettner 2003). This low DO condition is likely more the result of climatological conditions, such as high air temperatures and low wind speeds, than lake surface elevations because shallower depths would likely increase mixing of bottom waters and this increase DO concentrations.

Blooms of blue-green algae can also reach densities in the fall and winter high enough to prompt advisories by the State of Oregon, but it is unknown if these blooms are directly or indirectly impacting SNS in this reservoir, or if Project operations affect the blooms.

The minimum proposed elevation for the end of September of 4,798.1 ft (1,462.5 m) in Gerber Reservoir will likely provide adequate water depths for protection against winter kill of SNS, which has apparently not occurred in the past during cold weather events where this elevation was maintained (USFWS 2008).

Based on the stability of the SNS population in Geber Reservoir, and the fact that proposed Project operations will be unchanged from past operations, adverse effects from water quality are not likely to limit the persistence of SNS in Gerber Reservoir. Thus, the proposed action is likely to provide the recovery-support function of critical habitat for the SNS in Gerber Reservoir for water quality.

9.3.2.2.2 Effects to PCE 2—Spawning and Rearing Habitat

The proposed action is not anticipated to impact spawning habitat, the first component of PCE2. Access to Ben Hall and Barnes Valley Creeks, that are the two main Gerber Reservoir tributaries where SNS spawning occurs, requires a minimum reservoir elevation of about 4,805.0 ft (1,464.6 m) during the February through May spawning season (USFWS 2008). During very dry years, both Barnes Valley and Ben Hall Creeks typically have low spring flows that are unlikely to provide adequate upstream passage for spawning adults, regardless of lake elevations (USBR 2001a). During these conditions, spawning cues are also unlikely to be present. Although the Gerber Reservoir surface elevations at the end of September have been observed below the proposed minimum elevation of 4,798.1 ft (1,462.5 m) in 5 years during the POR (1931, 1960, 1961, 1991, and 1992), surface elevations of at least 4,805.0 ft (1,464.6 m) were reached in these years the following spring by the end of March (USBR 2012, Appendix 6B).

The effects of low water levels in Gerber Reservoir on SNS rearing habitat use, population size, age-class distribution, recruitment, or decreased body condition are not fully understood. However, available information (Barry et al. 2007a, Leeseberg et al. 2007) indicates that the Gerber Reservoir SNS population has remained viable (i.e., shows evidence of regular recruitment and high abundance) under the current management regime (USFWS 2008). Because the proposed action is unchanged from past operations, low lake elevations resulting from Project operations are unlikely to limit the persistence of SNS in Gerber Reservoir. Thus, the proposed action is likely to provide the recovery-support function of critical habitat for the LRS and the SNS in Gerber Reservoir for spawning and rearing habitat.

9.3.2.2.3 Effects to PCE 3—Food

No specific data concerning the availability of food in Gerber Reservoir exists; however, the USFWS believes this is probably not a limiting factor for the LRS and SNS that occur there. The reservoir contains a very large amount of habitat and is productive enough to maintain dense populations of zooplankton. Therefore, food availability is not adversely affected by the proposed action and this PCE supports the recovery-support function of critical habitat for the SNS in Gerber Reservoir.

9.3.2.3 Summary of Effects to LRS and SNS Critical Habitat Unit 2

In Clear Lake, there is no affect to water quality (PCE1), spawning habitat (a component of PCE2), and food availability (PCE3) from proposed Project operation. The proposed action is likely adversely affecting rearing habitat during droughts that are likely to occur once during the term of this BiOp. However, the effect is unlikely to impede the recovery-support function of critical habitat for the LRS and SNS in Clear Lake.

In Gerber Reservoir, there are no adverse effects to PCEs of critical habitat as a result of the implementation of the proposed action. This proposed action is a continuation of past actions and the SNS population there has shown evidence of frequent recruitment. Therefore, we assume critical habitat in Gerber Reservoir is supporting the recovery role for SNS.

We conclude that Unit 2 of critical habitat is supporting the recovery role for the LRS and SNS.

9.4 Cumulative Effects to Critical Habitat

Cumulative effects are those impacts of future State and private actions that are reasonably certain to occur within the area of the action subject to consultation. Future Federal actions will be subject to the consultation requirements established in section 7 of the Act and therefore, are not considered cumulative to the proposed action. The actions identified in section 8.6, *Cumulative Effects* to LRS and SNS, are the same actions considered for cumulative effects to critical habitat for LRS and SNS. Most of the non-Federal actions listed in Section 8.6 will improve water quantity, water quality, and habitat in areas that support listed suckers, including UKL and its tributaries and the Keno Reservoir. Screening will reduce entrainment of suckers and improve overall survival. Habitat restoration will increase the amount and quality of areas important to complete sucker life cycles. Water quality improvement projects will work towards addressing a major factor limiting listed sucker recovery in the Upper Klamath Basin. If water quality (PCE1) is improved in Keno Reservoir, this area would likely support a substantial population of adult suckers and/or provide habitat to support larval and juvenile suckers (PCE2) that eventually will return to UKL as adults. These actions may provide indirect beneficial effects to food for listed suckers (PCE3). Therefore, the effects of the proposed action, combined with future State, tribal, and private actions, will only result in beneficial cumulative effects to critical habitat for LRS and SNS over the term of this BiOp (10 years); however, none of the benefits can be quantified at this time because specific project details are not available.

10 LRS AND SNS INTEGRATION AND SYNTHESIS (Jeopardy and Destruction or Adverse Modification Determinations)

This LRS and SNS integration and synthesis section of this BiOp is the final step of USFWS' assessment of the risk posed to listed species and their critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (sections 0 and 9) to the *Environmental Baseline* (sections 7 and 9) and the *Cumulative Effects* (sections 8.6 and 9.4), to formulate our BiOp as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; and (2) appreciably reduce the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and their conservation needs, and the ability of critical habitat to provide for the recovery and survival of the species (ESA Section 4). Also considered here is the USFWS Director's memo of March 6, 2006, that reiterates the need for the 7(a)(2) analysis to include the effects of an action on the capacity of the recovery units to provide assigned survival and recovery functions.

10.1 Range-wide Status of the LRS and SNS and Their Environmental Baseline in the Action Area

In our *Status of the Species* (section 7), we described the factors that have led to the current status of the LRS and SNS as endangered throughout their range under the ESA, including a critical lack of resiliency and redundancy due to severe reductions of self-sustaining populations range wide and dramatic population declines and loss of important habitats and populations in large parts of their range (USFWS 2013). Self-sustaining populations with frequent recruitment only occurs in Gerber Reservoir and Clear Lake for SNS. LRS in Clear Lake show frequent recruitment, but recruitment is highly variable in magnitude, and one large cohort that appeared in population in 2007, had disappeared by 2009, so some unknown factor reduced their survival. Neither LRS nor SNS have recruited in significant numbers into the adult populations in UKL since the late 1990s. There is a population of LRS and SNS in Tule Lake Sump 1A, although the fish appear healthy, there is no evidence of spawning and it is believed that these fish immigrated to this sump from areas above it. Although suckers in Tule Lake are not known to reproduce, the 2013 Revised Recovery Plan identifies the importance of conserving these fish for redundancy to prevent extinction until other populations can be recovered. Thus, the only populations that appear to be stable are SNS in Clear Lake and Gerber Reservoir.

Specific factors limiting LRS and SNS recovery in UKL include higher than natural mortality of age-0 juveniles due to degraded water quality, algal toxins, disease, parasites, predation, competition with native and introduced species, and entrainment into water management structures. Adult populations in UKL are limited by negligible recruitment, stress and mortality associated with severely-impaired water quality, and the fact that adult suckers are approaching the limits of their life span. However, current survival rates of adult suckers in UKL are not unusually low in comparison to other long-lived species (Hewitt et al 2011). Additionally, these species are limited by a lack of connectivity throughout their range by dams, periodic low flows, and degraded habitat.

Because of a multi-decade lack of recruitment of LRS and SNS in UKL and their current old ages, both species will be at a high risk of extinction in the next 10 years without recruitment. A die-off of adult suckers in UKL, similar to those that occurred in the 1990s, would be catastrophic, especially for SNS because of its low abundance. Thus, their continued survival in UKL is dependent on recruitment in the near future. If the downward trend in the SNS population in UKL continues, the population could shrink to 1,000 in a decade. Thus, it is critical that a cohort recruit into the adult SNS population in the next 10 years.

In our *Environmental Baseline* (section 7), we described conditions that currently affect the survival and recovery of LRS and SNS within the action area, including: (1) adverse water quality (e.g., low DO, high ammonia, high pH, algal toxins, and urban and agricultural run-off) negatively affect suckers in UKL, Keno Reservoir, Lost River, Tule Lake, and in the Klamath River; (2) native and introduced pathogens, parasites, and predators could adversely affect all populations during droughts, but suckers in UKL are affected nearly every year by harsh conditions (e.g., low DO, high ammonia and pH, algal toxins, parasites, pathogens, and predators); (3) injury and mortality associated with entrainment into irrigation canals, turbines, and spillways at water control structures and dams affect the species throughout most of their range; (4) migration barriers such as dams prevent access to upstream spawning habitats in the Lost River and the Klamath River; additionally, adverse water quality and low flows could also act as seasonal barriers; (5) reductions in habitat quality and quantity resulting from diversion of water for agriculture seasonally reduce the amount of spawning and rearing habitats throughout their range, especially during droughts when water use increases; and (6) the species are negatively affected by range-wide reductions in habitat quality and quantity owing to droughts associated with natural climate cycles and manmade climate change.

Based on this, the environmental baseline for the species in the action area, which includes the majority of the species rearing habitats, is highly degraded and is contributing to their current imperiled status and likely poses a serious risk to their survival. Enforcement of State water-quality criteria and State water rights, and implementation of management plans associated with the Total Daily Maximum Loads (TMDL), and on-going restoration/enhancement of sucker habitat if implemented should improve the environmental baseline, but we are not able to predict when these actions will be done and exactly how they will benefit LRS and SNS populations. Furthermore, the long-term adverse effects of climate change require LRS and SNS populations have sufficient resilience and redundancy to withstand and adapt to the potentially increasing harsh future conditions potentially affecting both the amounts of water in sucker habitats and the quality of the water.

The effects of the proposed action on LRS and SNS are summarized below, based on recovery units identified in the recently revised recovery plan (USFWS 2013). The proposed action affects LRS and SNS in both recovery units (UKL and Lost River Basin), as well as LRS and SNS in the 8 management units; although, effects to the management unit downstream of Keno Dam are less substantial than at the other 7 units.

10.2 Summary of Effects UKL Recovery Unit

The UKL Recovery Unit includes LRS and SNS populations in UKL, Keno Reservoir, and the downstream hydropower reservoirs in the Klamath River (USFWS 2013). LRS are represented by a large population in UKL (50,000-100,000); however, few LRS (perhaps <1,000) are found downstream of UKL. SNS are found in UKL (less than 25,000), and in the Keno Reservoir and downstream hydropower reservoirs (less than 5,000). As described in the *Effects of the Action* (section 0), the proposed action is likely to result in a variety of effects to the LRS and SNS. Presented below is a summary of these effects.

Beneficial effects of the proposed action or of the proposed Conservation Measures that minimize impacts to LRS and SNS in UKL Recovery Unit are likely to include:

- Water storage in UKL during the winter will increase the amount of shoreline spawning, embryo, pre-swim-up larval, and larval habitat during the spring (March-June)
- Variable water levels in UKL will likely help maintain emergent marsh vegetation that requires air exposure for successful germination and growth of plant seedlings and support a variety of sucker nursery and rearing habitat.
- Water diversions during the irrigation season results in a net reduction of nutrients entering Keno Reservoir and downstream, as was concluded in 2010 TMDL (ODEQ 2010)

The proposed action, including Conservation Measures that will likely minimize adverse impacts of the Project to LRS and SNS in UKL Recovery Unit are likely to include:

- The A Canal fish screen minimizes entrainment of all life stages into the canal
- The Link River Dam fish ladder allows adult suckers in the Keno Reservoir to move upstream past the dam to UKL
- Canal salvage identified in the Conservation Measures will reduce the numbers of suckers that die in canals at the end of the irrigation season therefore minimizing entrainment effects
- Relocation of LRS and SNS from Lake Ewauna to UKL beginning in 2013 identified in the Conservation Measures will provide an immediate increase in adult spawning suckers in UKL and may provide adults of different age classes
- Financial and technical support for the controlled-propagation program identified in the Conservation Measures will enable the USFWS to begin rearing suckers in 2014 and will result in the production of substantial numbers of 8-inch juveniles that are likely to have higher survival rates than the larvae and age-0 suckers that are the primary life stages being adversely affected by the proposed action
- Participation and support by Reclamation for the Recovery Implementation Program identified in the Conservation Measures will advance the planning and implementation of sucker recovery efforts and expected to help offset adverse effects of the proposed action.
- Water will not be managed to minimums, but will be managed to provide variable UKL elevations dependent upon actual and forecasted inflows and water use conditions. UKL elevations will also be monitored to ensure that there is not a projected or realized progressive decrease in the expected distance above the thresholds identified in this BiOp and as monitored. If such a decrease happens, Reclamation will determine if they are operating within the scope of the proposed action and, therefore, what is covered by this BiOp. If necessary, Reclamation will consult with the USFWS to adaptively manage and take corrective actions.

Adverse effects of the proposed action to LRS and SNS in UKL Recovery Unit are likely to include:

- Diversion of water during dry years will decrease habitat for juvenile and adult suckers in late summer and that will reduce access to preferred habitats making suckers more vulnerable to bird predation
- Substantial entrainment of larvae and age-0 juvenile suckers will occur at the A Canal and Link River Dam
- Some entrainment of larvae and age-0 suckers will occur at Project diversions in the Keno Reservoir such as the Lost River Diversion Channel, Ady Canal, North Canal, and private diversions that use Project water
- Agricultural discharges from the Project will likely contribute to adverse water quality in Keno Reservoir and in downstream reservoirs. The 2010 TMDL for the Klamath and Lost River has waste load allocations attributed to agriculture for DO, pH, ammonia toxicity, chlorophyll-a, and temperature, and Reclamation, along with other agencies, was designated as a responsible governmental agency with "…legal authority over a sector or source contributing pollutants" (ODEQ 2010)
- Dewatering of canals as part of seasonal O&M operations at Project facilities is likely to strand any age-O juveniles present and is likely to make them vulnerable to bird predation.

10.3 Summary of Effects to the Lost River Basin Recovery Unit

The Lost River Recovery Basin Unit includes LRS and SNS populations in Clear Lake, Gerber Reservoir, Tule Lake, and the Lost River (USFWS 2013). SNS are found throughout the Lost River subbasin with the largest populations occurring in Clear Lake (less than 25,000) and Gerber Reservoir (less than 5,000). LRS are represented by a small population in Clear Lake (less than 10,000). LRS are rare in the Lost River and no LRS occurs in Gerber Reservoir. A small population (perhaps 500 total) of LRS and SNS occur in Tule Lake Sump 1A. As described in the *Effects of the Action* (section 8), the proposed action could have a variety of effects to the LRS and SNS. These effects are summarized below.

Beneficial effects of the proposed action to listed sucker populations in the Lost River Basin Recovery Unit are likely to include:

- Water storage in Clear Lake will increase habitat for suckers during some years (i.e., during average and above-average inflow conditions)
- Water storage in Gerber Reservoir will increase habitat for suckers in the spring
- Water releases from Clear Lake and Gerber Reservoir during the irrigation season increase habitat in the Lost River

The effects of proposed action, including Conservation Measures that minimize adverse impacts to LRS and SNS in the Lost River Basin Recovery Unit is likely to include:

- The Clear Lake fish screen prevents entrainment of 35-mm total length and larger suckers
- Maintenance of seasonal water levels in Tule Lake maximizes habitat for LRS and SNS within operational constraints

- Proposed salvage of suckers in canals around Tule Lake will minimize adverse effects of entrainment and seasonal dewatering.

Adverse effects of the proposed action on LRS and SNS in the Lost River Basin Recovery Unit are likely to include:

- Diversion of water from Clear Lake for agriculture during droughts decreases in habitat for all life-history stages and is likely to put suckers at increased risk of predation, disease and parasites, and diminished food availability
- Flow stoppage at the end of the irrigation season as a result of the proposed action will seasonally reduce or eliminate sucker habitat downstream of Clear Lake and Gerber Reservoir and could result in stranding of suckers
- Suckers entrained into Project facilities at Clear Lake, Gerber Reservoir, Tule Lake, and in the Lost River are likely to be harmed
- Agricultural discharges from private lands that use Project water are likely to contribute to adverse water quality in sucker habitats in the Lost River and Tule Lake through the release of nutrients, organics, and pesticides
- Dewatering of canals as part of seasonal O&M operations at Project facilities is likely to strand LRS and SNS and make them more vulnerable to bird predation.

The USFWS concludes, based on our analysis of the effects of the proposed action presented in the *Effects of the Action* (section 8) and summarized above, the most substantial effects to LRS and SNS in the UKL Recovery Unit are likely to be from entrainment of age-0 juveniles at the Link River Dam. This adverse effect is significant because of the large numbers of juveniles entrained annually and the important function these fish should serve by recruiting into the adult populations. Without this recruitment the populations cannot remain viable.

The most substantial effects of the proposed action to LRS and SNS in the Lost River Basin Recovery Unit are likely to be from the seasonal loss and degradation of habitat resulting from water diversions from Clear Lake during infrequent prolonged droughts. The reason for this is the substantial reductions that are likely to occur in habitat and potential for increased indirect effects such as predation, parasitism, and depletion of food, all of which could affect productivity (growth and fecundity) or even cause mortality. Although we have no known evidence that low lake levels in Clear Lake are affecting the LRS population viability, it is a concern.

10.4 Effects to LRS and SNS Population Viability

ESA Section 7(a)(2) requires the USFWS to make a decision regarding if the proposed action would likely result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. As was discussed in the *Status of the Species* (section 7), to both survive and to recover (i.e., to be viable), the LRS and SNS needs to have resiliency and redundancy, and that requires frequent recruitment and multiple populations, and that can only occur when there is adequate survival of all life stages from embryos to adults.

Currently in UKL, the population viability bottleneck for LRS and SNS appears to be low age-0 juvenile survival, as described in the *Status of the Species* (section 7). Based on the knowledge that juvenile survival is most likely putting LRS and SNS populations at risk of extinction, at least in UKL, the question that is perhaps most relevant here in relation to how the proposed action affects LRS and SNS population viability- *is the proposed action likely to cause appreciable reductions in survival of age-0 juveniles*? At Clear Lake and Gerber Reservoir, SNS appear to be experiencing frequent recruitment and good adult survival, and thus the viability of that species does not appear to be measurably affected by the proposed action. However, there is less certainty regarding how the proposed action will affect LRS in Clear Lake. Currently the LRS population in Clear Lake is experiencing frequent but highly variable recruitment, and one cohort that appeared in the adult population in 2007 later died. The cause of loss of the 2007 cohort is unknown, but because SNS appears to not be affected, it seems unlikely that Project operations are involved. However, because we do not fully understand LRS and SNS habitat needs and there are multiple potential ways that lake management could affect these species, adverse effects of lake-level management on LRS in Clear Lake cannot be ruled out.

Estimated entrainment losses of age-0 juveniles measured at the UKL outlet make it clear that thousands of larvae and age-0 juveniles are likely to be entrained from UKL every year. Furthermore, entrainment rates of age-0 juveniles are likely elevated by the proposed action because Link River flows during August and September, when of age-0 juveniles are present, are artificially increased by Reclamation in order to provide water for irrigation. Therefore, the proposed action is likely to cause appreciable reductions in survival of young suckers. Loss of age-0 juveniles is more of a concern than for larvae because juveniles should have a greater likelihood of recruiting into the adult population than larvae. Based on this, entrainment of young suckers is the effect of the proposed action that is most likely to cause appreciable reductions in survival of age-0 juveniles and therefore is likely to affect population viability. However, there are two minimizing factors that also need to be considered regarding the effect of the proposed action on population viability. These factors are controlled (or captive) propagation and relocation of adult suckers from Keno Reservoir to UKL.

As part of the conservation measures included in the BA, Reclamation proposes to relocate adult suckers from Keno Reservoir to UKL. Currently, there is no evidence that suckers in Keno Reservoir are a self-supporting population. The persistence of LRS and SNS in Keno Reservoir is likely dependent on suckers being entrained from UKL to maintain their numbers. Recent studies have documented that for unknown reasons, a very limited number of LRS (< 25/year), and no documented SNS, use the fish ladder at Link River Dam to migrate back to spawning areas associated with UKL. Therefore, at this time suckers in Keno Reservoir appears to be serving as a sink population. The 2013 Revised Recovery Plan (USFWS 2013) includes actions to continue to determine the limiting factors regarding use of the fish ladder as well as actions to restore habitat in Keno Reservoir to the extent that it will support a viable population. However, because it will be many years before the Keno Reservoir is restored, it makes more sense to relocate adult suckers in the reservoir to UKL so they can spawn.

Relocation of adults is scheduled to begin in 2013 and will supplement existing sucker population in UKL. Having more adults in the UKL populations that can reproduce will help improve their viability by adding further resiliency. Because most of suckers that will be relocated to UKL are SNS, the SNS population in UKL will benefit the most, which is important because that population is small and declining. Because we cannot get an accurate age estimate of these suckers without killing them (length-age estimates are high inaccurate because of slow growth), we are unsure of their ages. However, it is possible that they constitute a different age classes than suckers in UKL, thus increasing the survival time of adults in UKL.

Controlled propagation is the other minimizing factor to be considered when assessing if the proposed action reduces population viability. Reclamation has committed to provide funding for a multi-faceted controlled-propagation program. The purpose of the Reclamation funded portion of this program is to minimize the effects of their proposed action on LRS and SNS populations – not to produce sufficient suckers to achieve recovery. Because controlled propagation will be planned and implemented by the USFWS, the BA was necessarily vague about what effects the controlled-propagation program would likely have on LRS and SNS. To implement the propagation program, up to 30,000 to 40,000 eggs or 50,000 to 75,000 larvae will need to be removed from the wild each year, and some mortality is anticipated. The removal of this many eggs and larvae is not anticipated to adversely affect LRS and SNS populations because sucker eggs and larvae are produced in large numbers (i.e., millions every years) and their *in situ* survival is naturally low. Furthermore, we anticipate the overall effects of controlled propagation on LRS and SNS will likely be beneficial, given the success of other propagation programs, especially the June sucker program where the survival rate of stocked juveniles is high, as is explained below.

The USFWS has extensive expertise in fish propagation and fish health based on 70 national fish hatcheries, and has hatcheries such as the one in Dexter, New Mexico, that specialize in culture of imperiled fishes. The USFWS also has seven Fish Technology Centers and nine Fish Health Centers that provide technical support to hatchery programs, other USFWS offices, other Federal agencies, states, Indian tribes, and stakeholders.

The USFWS has successfully reared LRS and SNS to a large size from wild-collected larvae. Furthermore, considerable knowledge from other successful efforts to propagate closely related suckers species, especially the June sucker, will contribute to the development of a controlled-propagation program for the LRS and SNS. June suckers released at an 8-inch length into Lake Utah have a 30 percent survival rate, which is substantially greater than natural survival rates (Rasmussen et al. 2009, Billman et al. 2011). Based on techniques utilized to rear June suckers we anticipate that with approximately 1 acre of ponds located on the Lower Klamath Refuge, we will be able to rear 8,000 – 10,000, 8-inch long suckers in 2-3 years. Larvae put into ponds in 2014, will produce juveniles by April 2016 or 2017, at which time they will be released into UKL. We anticipate that propagated suckers will begin entering the reproductive populations beginning in 2019, which is 4 years before the term of this BiOp ends. The USFWS intends to use Reclamation's funding to expand the program beyond the planned efforts at the Refuge. This expansion will include investigating the feasibility of additional ponds and/or rearing net cage put into natural waters, and rearing facilities such as those used for June suckers using tanks with heated recirculating water. Although it is clear that the development of a multi-faceted controlled propagation, including Reclamation's conservation measures, must move forward to prevent extinction, it is difficult to predict the timing and results of future efforts at this point. Every effort will be made to find a viable alternative to expanding the work at the Refuge within the next three years so that we will realize additional benefits for the duration of the BiOp. In the interim, we anticipate the production in Refuge ponds and the relocation effort in Lake Ewauna to be sufficient to minimize adverse effects of entrainment and additional propagation will contribute to improving baseline conditions.

10.5 Conclusion for LRS and SNS

After reviewing the current status of the LRS and SNS, the effects of the proposed action and the cumulative effects, it is the USFWS' BiOp that the continued operation of the Project for a 10-year term is not likely to jeopardize the continued existence of the LRS and SNS or result in the destruction or adverse modification of their critical habitat. This BiOp does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. The USFWS reached this conclusion based on the following finding, the basis for which is presented in the preceding *Status of the Species* (section 7), *Environmental Baseline* (sections 7 and 9), *Effects of the Action* (sections 0 and 9), and *Cumulative Effects* (sections 8.6 and 9.4) of this BiOp.

10.6 Basis for the Conclusion Regarding Jeopardy for LRS and SNS

The USFWS' non-jeopardy determination for the effects of the proposed action on the LRS and SNS is based on the following. Going into the consultation, it was clear that the status and environmental baseline of the LRS and SNS was highly degraded, so that even small adverse effects to the species were likely to reduce their viability. Therefore, extensive coordination between Reclamation, NMFS, USFWS, and stakeholders occurred during the 2 years leading up to development of the proposed action. That effort resulted in a proposed action that includes higher seasonal UKL elevations and greater certainty that elevation goals would be met compared to previous proposed actions. However, substantial adverse effects would remain that could not be further minimized by modifying water management, such as entrainment at the Link River Dam. Consequently, we worked closely with Reclamation to propose specific conservation measures that would likely be most successful in further minimizing adverse effects. The goal of the conservation measures was to minimize the remaining adverse effects of the proposed action on population viability, thus making the action compatible with the survival and recovery needs of the species. The two most important conservation measures, relocation of adult suckers from Lake Ewauna to UKL and controlled propagation, would provide both an immediate increase in the reproducing adult sucker populations in UKL and also provide longer term production of large juvenile suckers that would likely survive and recruit into the adult populations during the term of the BiOp. Thus the adverse effects of the action on LRS and SNS could be minimized initially as well as over the term of the BiOp.

The USFWS anticipates that the controlled-propagation program and relocation program will minimize the effects of the proposed action such that appreciable reductions in the likelihood of both survival and recovery of LRS and SNS will not occur. This is based on the proposed funding levels coming from Reclamation, our expertise in fish culture and health, experience we have gained in rearing LRS and SNS, and knowledge we can use from other similar efforts that have successfully raised imperiled suckers similar to the LRS and SNS. Reclamation and the USFWS have also had experience salvaging and relocating fish with a high survival rate so we expect the relocation of suckers from Keno Reservoir to UKL to be successful and this will be determined by the presence of these tagged fish in the future at spawning sites. Additionally, propagation and relocation will ensure that the recovery function of the UKL Recovery Unit will be maintained.

Although we anticipate that actions by State, Tribal, and private organizations and individuals will improve the environmental baseline through environmental-restoration/enhancement programs, the extent of improvement is unknown. The effects of climate change on the environmental baseline during the term of this BiOp are of concern, however, those effects are already being realized in the Klamath Basin and thus were part of the environmental baseline that we analyzed.

Based on this information, the USFWS concludes that the proposed action is not likely to result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. Additionally, the proposed action is unlikely to appreciably reduce the capacity of the two recovery units to provide assigned survival and recovery functions for the LRS and SNS.

10.7 Basis for the Conclusion Regarding Destruction or Adverse Modification of Critical Habitat

In our *Effects of the Action* (section 9.3) of this BiOp we described how the proposed action was likely to affect the PCE's recovery-support function for LRS and SNS in the two recovery units (UKL and Lost River Basin). The primary recovery needs are for LRS and SNS populations to remain viable and that requires resiliency and redundancy.

The primary effect of the proposed action on critical habitat is the seasonal and longer term changes that occur owing to water storage and delivery. This results in increases of habitat in some seasons and in some years and decreases in others, so effects are both beneficial and adverse. For UKL, the proposed action was designed to better provide lake levels that meet the conservation needs of the species. Thus, seasonal lake levels are higher and there is more certainty that occurrences of low lake levels would be minimized in relationship to previous proposed actions for this Project.

In Unit 1, there is no causal link to adverse effects to water quality (PCE1) in UKL; however, there is evidence that water diversions through the Project cause a net reduction in nutrients downstream of UKL, which is beneficial. However, in Keno Reservoir, there are return flows into the reservoir from agricultural diversions that are part of the proposed action, resulting in some negative effects to water quality. The proposed Project does not affect food availability (PCE3) in Unit 1.

Proposed Project operations result in higher lake elevations in UKL in the spring and early summer which is protective and beneficial to the spawning habitat component of PCE2 in all but one of the 31 modeled years. Rearing habitat for age-0 juvenile suckers in Unit 1is adversely affected in 13 percent of the modeled years of the proposed action and will have a negative impact on the critical habitat ability to provide for adequate rearing habitat as part of the intended recovery role for the species. We do not believe this adverse effect will substantially reduce

LRS and SNS population resiliency or redundancy because of the low prevalence of adequate rearing habitat occurring in Keno Reservoir, more favorable rearing habitats occurring outside of Keno Reservoir, and the *Conservation Measures* proposed by Reclamation will compensate for the adverse effects on the PCEs via relocation of adult suckers from Keno Reservoir (also known as Lake Ewauna) to UKL and the production of juvenile suckers by the proposed controlled-propagation program.

We conclude that Unit 2 of critical habitat is supporting the recovery role for the LRS and SNS. In Unit 2, there is no affect to water quality (PCE 1), spawning habitat (a component of PCE2), and food availability (PCE 3) from proposed Project operation in Clear Lake. The proposed action is likely to adversely affect rearing habitat during droughts that are likely to occur once during the term of this BiOp. However, the effect is unlikely to impede the recovery-support function of critical habitat for the LRS and SNS in Clear Lake. In Gerber Reservoir, there are no adverse effects to PCEs of critical habitat as a result of the implementation of the proposed action. This proposed action is a continuation of past actions and the SNS population (the only listed sucker species in the reservoir) has shown evidence of frequent recruitment. Therefore, we assume critical habitat in Gerber Reservoir is supporting the recovery role for SNS.

In summary, the recovery-support function of critical habitat for LRS and SNS is anticipated to be most impacted by operations at Keno Reservoir through actions affecting PCEs 1 and 2. While these impacts are adverse they are temporary, rather than permanent, and the Conservation Measures proposed by Reclamation compensate for the impacts to the recovery role of critical habitat in Unit1. Critical habitat range-wide remains functional in most years and serves its intended recovery role of population resiliency and redundancy for these two species. Based on the information provided in this analysis, designated critical habitat is expected to continue to provide the recovery-support function of critical habitat for LRS and SNS at the scale of designated critical habitat, which is coincident with the range of LRS and SNS. Therefore, we do not anticipate that effects of the proposed action, taking into account cumulative effects, will result in the destruction or adverse modification of LRS and SNS critical habitat. We believe that the proposed action will not alter the essential physical or biological features to an extent that appreciably reduces the conservation value of critical habitat range-wide for LRS and SNS.

11 SONCC COHO SALMON CRITICAL HABITAT

NMFS has determined that the proposed action may adversely affect SONCC coho salmon critical habitat (64 FR 24049; May 5, 1999). Therefore, this BiOp analyzes the effects of the proposed action on SONCC coho salmon critical habitat using the following analytical approach.

11.1 Analytical Approach

Pursuant to section 7(a)(2) of the ESA, Federal agencies are directed to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Below, NMFS outlines the conceptual framework and key steps and assumptions used in the critical habitat destruction or adverse modification analysis.

11.1.1 Overview of NMFS' Assessment Framework

NMFS' "destruction or adverse modification" determinations are based on an action's effects on the conservation value of habitat that has been designated as critical to threatened or endangered species[3]. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, NMFS assesses if Primary Constituent Elements (PCEs; i.e., the principal biological or physical constituent elements within the designated area that are essential to the conservation of listed species) or essential features (i.e., those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection) included in the designation are likely to be affected by that exposure.

In this step of the assessment, NMFS must identify: (a) the spatial distribution of stressors and benefits produced by an action; (b) the temporal distribution of stressors and subsidies produced by an action; (c) changes in the spatial distribution of the stressors with time; (d) the intensity of stressors in space and time; (e) the spatial distribution of PCEs or essential features of designated critical habitat; and (f) the temporal distribution of PCEs or essential features of designated critical habitat.

If PCEs or essential features of designated critical habitat are likely to respond given exposure to the direct or indirect consequences of the proposed action, interrelated or interdependent actions, or both, NMFS assesses if those responses are likely to reduce the quantity, quality, or availability of those PCEs or essential features within the action area. The action area is organized by reaches within the mainstem Klamath River, the area encompassing the diversity

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[3] Several courts have ruled that the definition of destruction or adverse modification that appears in the ESA section 7 implementing regulations at 50 CFR 402.02 is invalid [e.g., *Gifford Pinchot Task Force v. USFWS*, 378 F.3d 1059 (9th Cir. 2004), amended by 387 F.3d 968 (9th Cir. 2004)], and NMFS does not rely on the invalidated definition for the determinations NMFS makes in this BiOp. Instead, NMFS relied on the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. As explain in the text, NMFS uses the "conservation value" of critical habitat for our determinations which focuses on the designated area's ability to contribute to the conservation of the species for which the area was designated.

stratum[4] (Interior Klamath) in which the affected PCEs or essential features are found, and then the overall designated area of critical habitat at the ESU scale. The basis of the analysis is to evaluate any appreciable reduction to the function and role of the critical habitat in the conservation of the species.

In this step of the assessment, NMFS identifies or makes assumptions about (a) the habitat's probable condition as the point of reference; (b) the ecology of the habitat at the time of exposure; (c) where the exposure is likely to occur; (d) when the exposure is likely to occur; (e) the expected intensity of exposure; (f) the likely duration of exposure; and (g) the frequency of exposure. NMFS recognizes that the conservation value of critical habitat, like the base condition of individuals and populations, is a dynamic property that changes over time in response to the environment (e.g., changes in land use patterns, climate (at several spatial scales), ecological processes, and changes in the dynamics of biotic components of the habitat). For these reasons, some areas of critical habitat in the action area might respond to an exposure when others do not. NMFS also considers how designated critical habitat is likely to respond to any interactions and synergisms between or aggregate effects of pre-existing stressors and anticipated project-related stressors.

As with the outline of the summary approach to how NMFS analyzes the effects from the proposed action on individuals, NMFS performs the following steps to help determine effects from the proposed action on designated critical habitat:

- Determine the critical habitat likely to be exposed to project-related stressors,
- Determine the area or features of critical habitat that could be affected by the proposed project,
- Determine which PCEs or essential features could be affected by project-related stressors,
- Estimate the stressor(s) frequency, intensity, and duration of exposure to critical habitat,
- Determine if there will be interactions between existing stressors and project stressors on critical habitat,
- Determine short-term responses of critical habitat to project-related stressors,
- Determine long-term responses of critical habitat to project-related stressors,
- Determine if the stressor and exposure scenarios anticipated are expected to result in an appreciable reduction in the quantity, quality, or function of critical habitat in the action area

If the quantity, quality, or availability of the PCEs or essential features of the area of designated critical habitat are reduced, NMFS evaluates if those reductions are likely to be sufficient to reduce the current conservation value of the designated critical habitat for listed species in the action area. In this step of the assessment, NMFS combines information about the contribution of PCEs or essential features of critical habitat to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those PCEs or essential features in the action area. NMFS

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[4] In cases where the extent of designated critical habitat is smaller than the boundaries of a defined area such as a diversity stratum, our analysis would focus on the extent of the designation within that area and not artificially extend critical habitat boundaries.

uses the *conservation value* of those areas of designated critical habitat that occur in the action area as the point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, then that limited value is the point of reference for the assessment.

If the conservation value of designated critical habitat in an action area is reduced due to the proposed action, the final step of the analysis assesses if those reductions are likely to be sufficient to reduce the overall conservation value of the entire designated critical habitat. In this step of the assessment, NMFS combines information about the PCEs or essential features of critical habitat that are likely to experience changes in quantity, quality, and availability given exposure to an action. NMFS uses the conservation value of the entire designated critical habitat as the point of reference for this comparison. For example, if the designated critical habitat has limited current value or potential value for the conservation of listed species that limited value is the point of reference for the assessment.

If the proposed action results in reductions in the quantity, quality, or availability of one or more essential features or PCEs, which in turn reduces the conservation value of the designated areas in the action area, which in turn reduces the function of the overall critical habitat designation in its relation to conservation of the species, then NMFS will conclude that the proposed action is likely to result in an adverse modification or destruction of critical habitat. In the strictest interpretation, reductions to any one essential feature or PCE would equate to a reduction in the value of the critical habitat in the action area. However, there are other considerations. NMFS looks to various factors to determine if the reduction in the value of an essential feature or PCE would affect the ability of critical habitat to provide for the conservation of the species.

11.1.2 Concept of the Natural Flow Regime

Throughout the BiOp, NMFS used the concepts of a natural flow regime (Poff et al. 1997) to guide its analytical approach. The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to multiple years), all without the influence of human activities (Poff et al. 1997). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff et al. 1997; Puckridge et al. 1998; Bunn and Arthington 2002; Beechie et al. 2006). Arthington et al. (2006) stated that simplistic, static, environmental flow rules are misguided and will ultimately contribute to further degradation of river ecosystems. Flow variability is an important component of river ecosystems which can promote the overall health and vitality of both rivers and the aquatic organisms that inhabit them (Poff et al 1997; Puckridge et al. 1998; Bunn and Arthington 2002; Arthington et al. 2006). Variable flows trigger longitudinal dispersal of migratory aquatic organisms and other large events allow access to otherwise disconnected floodplain habitats (Bunn and Arthington 2002), which can increase the growth and survival of juvenile salmon (Jeffres et al. 2008).

A universal feature of the hydrographs of the Klamath River and its tributaries is a spring pulse in flow followed by recession to a base flow condition by late summer (NRC 2004). This main feature of the hydrograph has undoubtedly influenced the adaptations of native organisms, as reflected in the timing of their key life-history features (NRC 2004). Life history diversity of

Pacific salmonids *Oncorhynchus spp*. substantially contributes to their persistence, and conservation of such diversity is a critical element of recovery efforts (Beechie et al. 2006). The findings of Waples et al. (2001) support the conclusion of Beechie et al. (2006) because they found life history and genetic diversity showed a strong, positive correlation with the extent of ecological diversity experienced by a species. The analysis by Williams et al. (2006) suggested that substantial environmental variability (e.g. wet coastal areas and arid inland regions) within the Klamath River Basin resulted in nine separate populations of coho salmon (see Status of the Species). Because aquatic species have evolved life history strategies in direct response to natural flow regimes (Taylor 1991; Waples et al. 2001; Beechie et al 2006), maintenance of natural flow regime patterns is essential to the viability of populations of many riverine species (Poff et al. 1997; Bunn and Arthington 2002).

Understanding the link between the adaptation of aquatic and riparian species to the flow regime of a river is crucial for the effective management and restoration of running water ecosystems (Beechie et al 2006), because humans have now altered the flow regimes of most rivers (Poff et al. 1997; Bunn and Arthington 2002). When flow regimes are altered and simplified, the diversity of life history strategies of coho salmon are likely to be reduced because life history and genetic diversity have a strong, positive correlation with the extent of ecological diversity experienced by a species (Waples et al. 2001). Any reductions in salmonid life history diversity are likely to have implications for their persistence (Beechie et al. 2006).

11.1.3 Flow and Rearing Habitat Analysis

NMFS used the relationships of flow and habitat formulated by Hardy (2012) and Hardy et al. (2006) to quantify how coho salmon fry and juvenile habitats vary with water discharge in the mainstem Klamath River below IGD. The flow-habitat relationships provided by Hardy et al. (2006) and Hardy (2012) represent the best available data on flow-habitat relationship in the Klamath River. NMFS is not aware of any other studies that quantify the relationship between discharge and habitat in the Klamath River mainstem.

Hardy et al. (2006) developed habitat suitability criteria for life history stages of anadromous salmonids in the regulated mainstem Klamath River based on the fundamental concepts of the ecological niche theory. The 2006 report defines an ecological niche as “the set of environmental conditions (e.g., temperature, depth, velocity) and resources (things that are consumed such as food) that are required by a species to exist and persist in a given location.” Species and life stage specific habitat suitability criteria used in instream flow determinations are an attempt to measure the important niche dimensions of a particular species and life stage (Gore and Nestler 1988). These criteria are then used to measure niche changes relative to changes in flow.

Empirical data on juvenile coho salmon in the mainstem Klamath River are limited. While juvenile outmigration monitoring (e.g., downstream migrant traps) provides information on distribution and emigration timing on the mainstem Klamath River, there are few observations of juvenile coho salmon utilizing micro-habitat. Consequently, Hardy et al. (2006) developed literature-based habitat suitability criteria to quantify habitat availability for juvenile coho salmon within the mainstem Klamath River. Habitat suitability criteria were validated using the limited empirical observations of coho salmon fry and parr in the mainstem Klamath River (Hardy et al. 2006).

Using simulated hydrodynamic variables at intensive study sites, Hardy developed composite suitability indices for each site from the habitat suitability criteria data, which incorporated species and life-stage specific preferences with regard to specific microhabitat features, such as flow, depth, velocity, substrate, and cover characteristics. The composite suitability indices were later converted into a combined measure known as the weighted usable area (WUA) to characterize the quality and quantity of habitat in terms of usable area per 1,000 linear feet of stream (NRC 2008). Hardy et al. (2006) then scaled up WUA results from the individual sites to the larger reach-level scale (see Hardy et al. 2006 or NRC 2008 for further discussion). WUA is a measure of habitat suitability, predicting how likely a habitat patch is to be occupied or avoided by a species life stage at a given time, place, and discharge (i.e., the suitability of the habitat for a specific species and life-stage of fish; NRC 2008).

NMFS uses reach-level WUA curves to gauge the general change in instream habitat availability (incorporating both quantity and quality) within the mainstem Klamath River resulting from the proposed action, and characterizes the change as a difference in suitable habitat volume. NMFS uses WUA curves from reach-level study sites for the Upper Klamath and Middle Klamath River reach effects analyses (Table 11.1).

Table 11.1. Hardy et al. (2006) and Hardy (2012) reach-level study sites used by NMFS for analysis.

Klamath River Reach	**Coho Salmon Fry**	**Coho Salmon Juvenile***
Upper Klamath River Reach	IGD to Shasta River	Trees of Heaven
	Shasta to Scott rivers	
	Parts of Scott to Salmon rivers	Seiad Valley
Middle Klamath River Reach	Parts of Scott to Salmon rivers	Rogers Creek
*While Hardy et al. (2006) developed WUA curves for coho salmon juveniles at seven reaches in the Klamath River, NMFS uses only the Trees of Heaven, Seiad Valley, and Rogers Creek reaches because these reaches have relatively high habitat availability and are most influenced by the proposed action (i.e., closest to IGD).		

Unlike the previous BiOp (NMFS 2010a), Reclamation did not model a No-Project flow scenario. The No-Project hydrology was used to describe a reference condition of a hydrological setting with all aspects of the baseline other than Reclamation's discretionary actions, thereby providing the Services with a reference condition to evaluate the effects of Reclamation's proposed action on UKL elevations and Klamath River flows below IGD. A No-Project flow scenario for the Klamath River is dependent upon a number of critical assumptions (e.g., designating the UKL outflow elevation, Refuge deliveries, Lost River diversions to and from the Klamath River, and other water routing assumptions that influence the magnitude, timing and duration of flows in the Klamath River). While anthropogenic factors influencing water availability and routing outside of Reclamation's discretion remain in a No-Project flow scenario, actions and elements of the baseline within Reclamation's discretion are removed from the hydrological setting under a No-Project scenario.

In 2007, Reclamation provided NMFS and USFWS a No-Project hydrology that included critical assumptions given a hypothetical scenario in which Reclamation would no longer deliver water to the Klamath Project. Key assumptions included: (1) UKL will be a level pool and not affected by wind; and (2) the reef at Link River dam would be reconstructed, recreating the original reef elevation stage-discharge relationship (NMFS 2010a).

Prior to completing Reclamation's 2012 BA, the Services and Reclamation discussed the potential of developing a No-Project hydrology for this consultation. NMFS, USFWS, and Reclamation mutually agreed, during informal consultation, that developing a No-Project hydrology for the purpose of analyzing the effects of Reclamation's proposed action on listed species was not prudent because the agencies were not able to find consensus on approaches to address critical assumptions necessary to define a No-Project condition. Concerns with the above-described assumptions, combined with the Services' determination that their analytical approach was not dependent on a No-Project hydrology led Reclamation to not model a No-Project hydrology. NMFS determined on January 8, 2013, it had sufficient information to initiate formal consultation based on the biological assessment, and NMFS and USFWS have since proceeded with formal consultation and drafting the joint BiOps based on the biological assessment and critical assumptions described in this BiOp.

On April 8, 2013, the Hoopa Valley Tribe submitted to NMFS, model output from a No-Project hydrological scenario and associated flow/habitat relationship data, analyzing habitat availability under a No-Project hydrology. NMFS has not had sufficient resources to do more than a cursory evaluation of the model structure and assumptions supporting the No-Project hydrological scenario, nor has it had sufficient resources to evaluate it with USFWS and Reclamation, while also proceeding with drafting the BiOp as required under the ESA and implementing regulations.

While NMFS is appreciative of the Tribe's efforts to advance our understanding of the effects of the Proposed Action, NMFS has identified some potential problems with the model structure and assumptions in NMFS' cursory review of it, and NMFS is cautious of using hydrological data in which the critical assumptions of water routing have not been evaluated by Reclamation, USFWS, and NMFS. However, NMFS will further evaluate the No-Project hydrological scenario in coordination with Reclamation and USFWS to determine whether it is a reasonable representation of no-project flows and reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered. If so, reinitiation of formal consultation will be required under 50 CFR 402.16.

Therefore, NMFS does not use a modeled No-Project flow to quantitatively compare the flow effects of the proposed action for this consultation. However, NMFS can reasonably assume the proposed action reduces mainstem flow volume in the Klamath River throughout most of the year because the Project diverts water during the spring and summer (and fall and winter to a lesser degree) and stores water in UKL in the fall and winter. Using Hardy's (2012) coho salmon fry and Hardy et al.'s (2006) juvenile data, NMFS identified the range of flows for the mainstem reaches downstream of IGD where there is a positive correlation between flow and habitat availability. In those flow ranges, when flows increase, habitat availability increases. Conversely, when flows decrease, habitat availability decreases in those flow ranges. Therefore, when the proposed action reduces mainstem flows within those ranges, the proposed action reduces habitat availability.

Like the previous BiOp (NMFS 2010a), NMFS assumes at least 80 percent of maximum available habitat provides for the conservation needs of coho salmon, and excludes flows that provide at least 80 percent of maximum available habitat from the analysis. NMFS then highlights the time periods and flow exceedances when the proposed action will reduce habitat availability below 80 percent of maximum available habitat for each reach. Instream maximum available habitat of 80 percent has been used to develop minimum flow needs for the conservation of anadromous salmonids (Sale et al. 1981 *in* Clipperton et al. 2002, NMFS 2002, Alberta Environment and Department of Fisheries and Oceans Canada 2007, Hetrick et al. 2009). Therefore, NMFS assumes that at least 80 percent of maximum available habitat provides a wide range of conditions and habitat abundance in which populations can grow and recover. Where habitat availability is 80 percent or greater under the proposed action, habitat is not expected to limit individual fitness or population productivity or distribution nor adversely affect the function of essential features of coho salmon critical habitat.

NMFS is aware of the limitations of focusing solely on WUA analysis when analyzing an individual coho salmon or coho population's response to an action (e.g., NRC 2008). For example, whether or not individuals actually occupy suitable habitat is dependent on a number of factors that may preclude access, including connectivity to the location, competition with other individuals, and risks due to predation (Hardy et al. 2006). Like all models, the instream flow model developed by Hardy et al. (2006) is an imperfect representation of reality (NRC 2008), and uncertainty exists in the model. Thus, NMFS' analysis focuses on habitat availability, as well as other important components of the flow regime, like water quality, channel function, and hydrologic behavioral cues, and how they affect coho salmon individual fitness.

Hardy et al. (2006) discussed the concept of an ecological base flow for the Klamath River. The ecological base flow (also called environmental flow) represents the minimum flow where any further anthropogenic reductions would result in unacceptable levels of risk to the health of aquatic ecosystem (Tharme 2003, Arthington et al. 2006, Hardy et al. 2006, Beca 2008, Ohlson et al. 2010). Hardy et al. (2006) adopted an ecological base flow for the Klamath River that is equivalent to the monthly 95 percent exceedance level of their instream flow recommendations.

With regard to Hardy et al.'s (2006) instream flow recommendations, including the ecological base flow, for the mainstem Klamath River, NMFS notes the different objectives and standards for analyses in Hardy et al. (2006) and this BiOp. Specifically, Hardy et al. (2006) used a multi-species approach to develop flow recommendations for conserving the entire suite of anadromous salmonids inhabiting the Klamath River Basin. In contrast, NMFS must focus its jeopardy and critical habitat analyses upon the effects of the proposed action on listed species (i.e., SONCC coho salmon) and critical habitat designated for listed species. Nevertheless, Hardy et al.'s (2006) instream flow recommendations provide NMFS with a useful reference when analyzing expected flows under the proposed action. Hardy et al.'s (2006) instream flow recommendations were based on the natural flow paradigm that concludes effective instream flow prescriptions should mimic processes characteristic of the natural flow regime (Poff et al. 1997, NRC 2005). Therefore, the Hardy et al. (2006) instream flow recommendations, particularly the ecological base flows, are useful in our analysis as an indicator of how closely the expected outcomes of the proposed action align with the patterns and processes of a natural flow regime.

11.1.4 Evidence Available for the Consultation

To conduct these analyses, NMFS considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. The following provides a list of some of the main resources NMFS considered:

- Final rule affirming the listing of the SONCC coho salmon ESU as threatened (70 FR 37160; June 28, 2005)
- Final rule designating critical habitat for the SONCC coho salmon ESU (64 FR 24049; May 5, 1999)
- Public draft of the SONCC coho salmon recovery plan (NMFS 2012a)
- NMFS' 2010 BiOp on the Klamath Project (NMFS 2010)
- NRC's assessment of Klamath River Basin fishes, hydrology, and the Services' BiOps on Reclamation's Project (NRC 2002a, 2004, 2008).

During the consultation, NMFS also used search engines to conduct electronic searches of the general scientific literature, including Aquatic Sciences and Fisheries Abstracts, Google, and Google Scholar. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests salmon will show a particular response to a potential stressor), as well as data that does not support that conclusion. NMFS stopped searching for scientific information on May 3, 2013, so that the BiOp could be completed.

11.1.5 Critical Assumptions

To address the uncertainties related to the proposed action effects and species responses, NMFS relied on a set of key assumptions that are critical to our effects analysis on listed species and their critical habitats. While other assumptions could be found elsewhere in this BiOp, the assumptions listed here are especially critical to analyzing effects of the proposed action. If new information indicates an assumption in the following table (or in other sections of the BiOp) is invalid, Reclamation and NMFS may be required to reassess the effects of the proposed action on listed species and their critical habitat, and reinitiate consultation, if warranted.

Table 11.2. List of critical assumptions made to address uncertainties.

Project Elements	Assumption
Environmental Water Account	Accretions from Link River Dam to IGD will be consistent with accretion timing, magnitude, and volume for the period of record.
	Water deliveries to the Project and off the Project will be consistent with average historical distribution patterns.
	The upper Klamath River basin will experience water year types within the range observed in the POR, and Williamson River inflows will be within the range observed in the POR.
	Accretions from Link River Dam to IGD will be routed through PacifiCorp's hydroelectric reach in a manner that is consistent with the proposed action modeled results for the period of record.
	Implementation of the proposed action will not exactly replicate the modeled results, and actual IGD flows and Upper Klamath Lake elevations will differ during real-time operations.
Restoration Activities	Starting in 2013, Reclamation will provide at least $500,000 annually for fish habitat restoration in the action area, and habitat restoration will be implemented each year of the proposed action.
Disease Monitoring for Adaptive Management	Reclamation will provide sufficient funding to support annual near real-time monitoring of *C. shasta* actinospore genotype II concentrations in the mainstem Klamath River immediately upstream of Beaver Creek (or an appropriate location[s] that Reclamation and NMFS determine in the future as new information becomes available).

11.2 Status of SONCC Coho Salmon Critical Habitat

Critical habitat for the SONCC coho salmon ESU was designated in 1999, and includes all accessible waterways, substrate, and adjacent riparian zones between Cape Blanco, Oregon, and Punta Gorda, California (64 FR 24049; May 5, 1999). Excluded are: (1) areas above specific dams identified in the Federal Register notice; (2) areas above longstanding natural impassible barriers (i.e., natural waterfalls); and (3) tribal lands.

SONCC coho salmon ESU critical habitat can be separated into five essential habitat types of the species' life cycle. The five essential habitat types include: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Essential habitats 1 and 5 are often located in small headwater streams and side channels, while essential habitats 2 and 4 include these tributaries as well as mainstem reaches and estuarine zones. Growth and development to adulthood (essential habitat 3) occurs primarily in near-and off-shore marine waters, although final maturation takes place in freshwater tributaries when the adults return to spawn. Within these areas, essential features of coho salmon critical habitat include adequate: (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (64 FR 24049; May 5, 1999).

11.2.1 Current Condition of Critical Habitat at the ESU Scale

Because the diversity of life history strategies of coho salmon include spending one and sometimes up to two years rearing in freshwater (Bell and Duffy 2007), they are especially susceptible to changes within the freshwater environment, more so than fall-run Chinook salmon, which migrate to the ocean shortly after emerging from spawning gravels. The condition of habitat throughout the range of the SONCC coho salmon ESU is degraded, relative to historical conditions. While some relatively unimpaired streams exist within the ESU, decades of intensive timber harvesting, mining, agriculture, channelization, and urbanization have altered coho salmon critical habitat, sometimes to the extent that it is no longer able to support one or more of the life stages of coho salmon. Below, NMFS provides a summary of the condition of the essential habitat and essential features of critical habitat designated for the SONCC coho salmon ESU (64 FR 24049; May 5, 1999).

11.2.1.1 Juvenile Rearing Areas

Juvenile rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification. In the SONCC coho salmon ESU, juvenile rearing areas have been compromised by low flow conditions during the late spring and summer, high water temperatures during the summer, insufficient dissolved oxygen concentration levels during the summer and early fall, excessive nutrient loads, invasive species, habitat loss, pH fluctuations, sedimentation, removal or non-recruitment of large woody debris, stream habitat simplification, and loss of riparian vegetation. The quality of many winter rearing areas for SONCC ESU coho salmon are degraded by high water velocities due to excessive surface runoff during storm events, suspended sediment, removal or non-recruitment of large woody debris and stream habitat simplification. Changes to streambeds and substrate, as well as removal of riparian vegetation, have limited the amount of invertebrate production in streams, which has in turn limited the amount of food available to rearing juveniles. Some streams in the ESU remain somewhat intact relative to their historical condition. However, the majority of the waterways in the ESU fail to provide sufficient juvenile rearing areas.

11.2.1.2 Juvenile Migration Corridors

Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. Adequate juvenile migration corridors need to be maintained throughout the year because smolts emigrate to estuaries and the ocean from the early spring through the late summer, while juveniles may redistribute themselves at any time in response to fall freshets or while seeking better habitat and rearing conditions. In the ESU, juvenile migration corridors suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. Low DO levels, excessive nutrient loads, insufficient pH levels and other water quality factors also afflict juvenile migration corridors.

11.2.1.3 Adult Migration Corridors

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas. During this time of year, suspended sediment makes respiration for adults difficult. Removal or non-recruitment of woody debris and stream habitat simplification limits the amount of cover and shelter needed for adults to rest during high flow events. Low flows in streams can physically hinder adult migration, especially if fall rain storms are late or insufficient to raise water levels enough to ensure adequate passage. Poorly designed culverts and other road crossings have truncated adult migration corridors and cut off hundreds of miles of stream habitat throughout the SONCC coho salmon ESU. While adult migration corridors are a necessary step in the lifecycle for the species, the condition of this particular essential habitat type in the ESU is probably not as limiting, in terms of recovery of the species, as other essential habitat types, such as juvenile summer and winter rearing areas.

11.2.1.4 Spawning Areas

Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition and egg to fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU. A widespread problem throughout the ESU is sedimentation and embedding of spawning gravels, which makes redd building for adults difficult and decreases egg-to-fry survival. Excessive runoff from storms, which causes redd scouring, is another issue that plagues adult spawning areas. Low or non-recruitment of spawning gravels is common throughout the ESU, limiting the amount of spawning habitat.

11.2.1.5 SONCC Coho Salmon ESU Critical Habitat Summary

The current function of the majority of critical habitat in the SONCC coho salmon ESU has been degraded and fails to support functioning essential habitat features. Although there are exceptions, the majority of streams and rivers in the ESU have impaired habitat. Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing human activities. For example, large dams, such as William L. Jess Dam on the Rogue River in Oregon, stop the recruitment of spawning gravels and large wood, which impacts both an essential habitat type (spawning areas) as well as an essential feature of spawning areas (substrate). Water use in many regions throughout the ESU reduces summer base flows, which limits the establishment of several essential features such as water quality and water quantity.

11.2.2 Factors Affecting SONCC Coho Salmon Critical Habitat

11.2.2.1 Water Diversions and Habitat Blockages

Stream-flow diversions are common throughout the species' ranges. Unscreened diversions for agricultural, domestic and industrial uses are a significant factor for salmonid declines in many basins. Reduced stream-flows due to diversions reduce the amount of habitat available to salmonids and can degrade water quality, such as causing water temperatures to elevate more easily. Reductions in the water quantity will reduce the carrying capacity of the affected stream reach. Where warm return flows enter the stream, fish are likely seek reaches with cooler water, thus increasing competitive pressures in other areas.

Hydropower, flood control, and water supply dams of different municipal and private entities, particularly in the Klamath Basin, have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Since 1918, the completion of Copco 1 Dam (RM 198.6) has blocked coho salmon access into upstream reaches of Klamath River and tributaries. In addition, the construction of IGD in 1961 further blocked coho salmon access upstream of RM 190. On the Eel River, the construction of the Potter Valley Project dams in 1908 has blocked access to a majority of the historic salmonid habitat within the mainstem Eel River watershed. As a result of migration barriers, salmon and steelhead populations have been confined to lower elevation mainstem reaches that historically only were used for migration and rearing. Population abundances have declined in many streams due to decreased quantity, quality, and spatial distribution of spawning and rearing habitat (Lindley et al. 2007). Higher temperatures at these lower elevations during late-summer and fall are also a major stressor to adult and juvenile salmonids.

11.2.2.2 Timber Harvest

Timber harvest and associated activities occur over a large portion of the range of the ESU. Timber harvest has caused widespread increases in sediment delivery to channels through both increased land sliding and surface erosion from harvest units, roads, and log decks. Significant amounts of old-growth and late-seral second-growth riparian vegetation along spawning streams has been removed, reducing future sources of large woody debris needed to form and maintain stream habitat that salmonids depend on during various life stages.

The potential for delivering sediment to streams increases as hillslope gradients increase (Murphy 1995). The soils in virgin forests generally resist surface erosion because their coarse texture and thick layer of organic material and moss prevent overland flow (Murphy 1995). Activities associated with timber management decrease the ability of forest soils to resist erosion and contribute to fine sediment in the stream. Yarding activities that cause extensive soil disturbance and compaction can increase splash erosion and channelize overland flow. Site preparation and other actions which result in the loss of the protective humic layer can increase the potential for surface erosion (Hicks et al. 1991). After harvesting, root strength declines, often leading to slumps, landslides, and surface erosion (Forest Ecosystem Management Assessment Team 1993, Thomas et al. 1993).

In fish-bearing streams, woody debris is important for storing sediment, halting debris flows, and decreasing downstream flood peaks, and its role as a habitat element becomes directly relevant for Pacific salmon species (Reid 1998). Large woody debris alters the longitudinal profile and reduces the local gradient of the channel, especially when log dams create slack pools above or plunge pools below them, or when they are sites of sediment accumulation (Swanston 1991). Cumulatively, the increased sediment delivery and reduced woody debris supply have led to widespread impacts to stream habitats and salmonids. These impacts include reduced spawning habitat quality, loss of pool habitat for adult holding and juvenile rearing, loss of velocity refugia, and increases in the levels and duration of turbidity which reduce the ability of juvenile fish to feed and, in some cases, may cause physical harm by abrading the gills of individual fish. These changes in habitat have led to widespread decreases in the carrying capacity of streams that support salmonids.

11.2.2.3 Climate Change

New information since this SONCC coho salmon ESU was listed suggests that the earth's climate is warming, and that this change could significantly impact ocean and freshwater habitat conditions (Intergovernmental Panel on Climate Change 2007), which affects survival of coho salmon. In the coming years, climate change will influence the ability to recover some salmon species in most or all of their watersheds. Of all the Pacific salmon species, coho salmon are likely one of the most sensitive to climate change due to their extended freshwater rearing. Additionally, the SONCC coho salmon ESU is near the southern end of the species' distribution and many populations reside in degraded streams that have water temperatures near the upper limits of thermal tolerance for coho salmon. For these reasons, climate change poses a new threat to the viability of the SONCC coho salmon ESU. Across the entire range of the SONCC coho salmon ESU, there are likely to be dramatic changes in the spatial structure, diversity, abundance, and productivity. Together these changes are likely to influence the future viability of individual populations, as well as the overall viability of the ESU.

Specific factors of a population or its habitat that could influence its vulnerability to climate change include its reliance on snowpack, current temperature regime (how close is it to lethal temperatures already), the extent of barriers that block access to critical habitat and refugia areas, the range of ecological processes that are still intact, and the current life history and genetic diversity.

Water temperature is likely to increase overall, with higher high temperatures along with higher low temperatures in streams. A recent study in of the Rogue River basin determined that annual average temperatures are likely to increase from 1 to 3 °F (0.5 to 1.6 °C) by around 2040, and 4 to 8 °F (2.2 to 4.4 °C) by around 2080. Summer temperatures are likely to increase dramatically reaching 7 to 15 °F (3.8 to 8.3 °C) above baseline by 2080, while winter temperatures are likely to increase 3 to 8°F (1.6 to 3.3 °C) (Doppelt et al. 2008). Changes in temperature throughout the range of the SONCC coho salmon ESU are likely to be similar. The increases in temperature within a specific stream or stream reach will depend on factors such as riparian condition, groundwater and spring influence, the presence of upstream impoundments, and stream flow (Bartholow 2005). Increases in winter and spring temperature regimes are likely to cause eggs to develop more quickly, leading to early emergence. Early SONCC coho salmon fry are likely to be disoriented or displaced downstream during high spring flows, which increases their exposure to predators or the ocean prematurely. Higher spring temperatures will increase the growth rates of fry; however, increases in summer temperatures will lead to thermal stress and decreased growth and mortality of juveniles.

The increase in summer water temperatures are likely to be especially dramatic since flows in many streams are expected to continue decreasing as a result of decreasing snowpack (Luers et al. 2006, Crozier et al. 2008, Doppelt et al. 2008). Recent projections indicate that snowpack in northern California and southern Oregon will decrease by 60 to 75 percent by 2040 and will disappear almost completely by 2080 (Doppelt et al. 2008). Levels will be less than 10 inches snow water equivalent in the few areas where snowpack remains (Luers et al. 2006, Doppelt et al. 2008). This loss of snowpack will continue to create lower spring and summertime flows while additional warming will cause earlier onset of runoff in streams. Depending on the timing of upwelling and ocean conditions, changes in the timing of runoff will shift downstream migration timing to be earlier and are likely to influence the survival of SONCC coho salmon smolts.

Annual precipitation could increase by up to 20 percent over northern California. Most precipitation during the mid-winter months is likely to occur as intense rain and rain-on-snow events that are likely to lead to higher numbers of landslides and greater and more severe floods (Luers et al. 2006, Doppelt et al. 2008). Overall, there will be earlier and lower low-flows and earlier and higher high-flows. Increased flooding is likely to scour eggs from their redds and displace overwintering juveniles, while lower low flows are likely to increase summer water temperatures.

Marine ecosystems face an entirely unique set of stressors related to global climate change, some of which are likely to have deleterious impacts on coho salmon growth and survival while at sea. In general, the effects of changing climate on marine ecosystems are not well understood given the high degree of complexity and the overlapping climatic shifts that are already in place (e.g., El Niño, La Niña, and Pacific Decadal Oscillation) and will interact with global climate changes in unknown and unpredictable ways. Current and projected changes in the North Pacific include rising sea surface temperatures that increase the stratification of the upper ocean; changes in surface wind patterns that impact the timing and intensity of upwelling of nutrient-rich subsurface water; and increasing ocean acidification which will change plankton community compositions with bottom-up impacts on marine food webs (Independent Scientific Advisory Board 2007). Ocean acidification also has the potential to dramatically change the phytoplankton community due to the likely loss of most calcareous shell-forming species such as pteropods. Recent surveys show that ocean acidification is increasing in surface waters off the west coast, and particularly off northern California, even more rapidly than previously estimated (Feely et al. 2008). For coho salmon, shifts in prey abundance, composition, and distribution are the indirect effects of these changes.

Direct effects to coho salmon likely include decreased growth rates due to ocean acidification and increased metabolic costs due to the rise in sea surface temperature (Portner and Knust 2007). Another consequence is that salmon must travel further from their home streams to find satisfactory marine habitat, which will increase energy demands, slow growth and delay maturity

(Independent Scientific Advisory Board 2007). Coho salmon typically do well when ocean conditions are cool and upwelling occurs.

Global average surface temperature has increased by approximately 0.7°C during the 20th Century (Intergovernmental Panel on Climate Change 2007) and appears to be accelerating, and the global trend over the past 50 years is nearly twice that rate. Regional trends in temperature show even greater warming tendencies. In general, conditions in the climate and within the ecosystems on which coho salmon rely will change dramatically and at an ever-increasing rate. In the near future, climate change will likely surpass habitat loss as the primary threat to the conservation of species in most if not all regions (Thomas et al. 2004). Climate change is having, and will continue to have, an impact on salmonids throughout the Pacific Northwest and California (Battin et al. 2007). Overall, climate change is believed to represent a growing threat for the SONCC coho salmon ESU, and will challenge the resilience of coho salmon.

11.2.2.4 Watershed Restoration

Since the 1990s, a variety of stakeholders and agencies have undertaken fisheries habitat restoration projects that benefit the SONCC coho salmon ESU. Today, there are various restoration and recovery actions underway across the SONCC coho salmon ESU aimed at removing barriers to salmonid habitat and improving habitat and water quality conditions for anadromous salmonids. Watershed restoration activities have improved freshwater habitat conditions in some areas, and are helping to reduce the stressors to the SONCC coho salmon ESU. The CDFW created both a multi-stakeholder coho recovery team to address range-wide recovery issues, and a sub-working group (Shasta –Scott Recovery Team) to develop coho salmon recovery strategies associated specifically with agricultural management within the Scott and Shasta rivers to return coho salmon to a level of viability so that they can be delisted. The CDFW has been prioritizing restoration proposals that are consistent with the coho salmon recovery strategies for funding under the Fisheries Restoration Grant Program. NMFS, FWS, USDA Forest Service, NRCS and local resource conservation districts have implemented fisheries habitat restoration throughout southern Oregon and Northern California.

Since 2005, several significant fish passage improvements have occurred throughout the ESU. In the Rogue River, three dams have been recently removed (i.e., Savage Rapids Dam in 2009, Gold Hill Dam in 2008, and Gold Ray Dam in 2010) and one notched (i.e., Elk Creek Dam in 2008) to restore natural flow and fish passage. The Rogue River now flows unimpeded for 157 miles from the Cascade foothills to the ocean, increasing salmon returns by an estimated 22 percent (NMFS 2010b). In addition, 75 barriers in the California portion of the SONCC ESU have been remediated since 2005, through the CDFW’s Fisheries Restoration Grant Program (Carpio 2010). Overall, coho salmon passage has improved. However, barriers remain a major threat because many are still unaddressed and continue to block passage.

In addition, the five northern California counties affected by the Federal listing of coho salmon (which includes Humboldt County) have created a 5 County Conservation Plan that establish continuity among the counties for managing anadromous fish stocks (Voight and Waldvogel 2002). The plan identifies priorities for monitoring, assessment, and habitat restoration projects. The Bear Creek Watershed Council (Rogue River tributary) is developing restorative, enhancement, and rehabilitative actions targeted at limiting factors. Similarly, several assessments have been completed for the Oregon coast in coordination with the Oregon Watershed Enhancement Board. These plans and assessments are helping to reduce, or stabilize, sediment inputs into streams throughout the ESU. Additionally, in areas where riparian vegetation has been replanted or enhanced, stream temperatures and cover for salmonids has been positively affected.

11.3 Environmental Baseline of Coho Salmon Critical Habitat in the Action Area

Endangered Species Act regulations define the environmental baseline as "…the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02). The "effects of the action" include the direct and indirect effects of the proposed action and interrelated or interdependent activities "…that will be added to the environmental baseline" (50 CFR 402.02). Implicit in both these definitions is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of ongoing Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to natural processes, are all part of the environmental baseline, to which effects of the proposed project are added for analysis.

Designated critical habitat for the SONCC coho salmon ESU in the action area is in the mainstem Klamath River downstream of IGD. Within the action area, the essential habitat types of SONCC coho salmon ESU designated critical habitat are: (1) Juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) adult migration corridors; and (4) spawning areas. Areas for growth and development to adulthood are not covered in this critical habitat section because these areas are restricted to the marine environment for coho salmon, which is not in the action area. Within the essential habitat types, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (64 FR 24049; May 5, 1999).

Juvenile summer and winter rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification. Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. Adequate juvenile migration corridors need to be maintained throughout the year because smolts emigrate to estuaries and the ocean from the early spring through the late summer, while juveniles may redistribute themselves at any time in response to fall freshets or while seeking better habitat and rearing conditions. Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas. Spawning areas for the SONCC coho salmon ESU must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition and egg to fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU.

The action area encompasses habitat for one entire diversity stratum (out of seven) as well as one population in another stratum in the SONCC coho salmon ESU. Coho salmon that inhabit the action area occupy temperate coastal regions as well as arid inland areas stretching from IGD to the north, all the way to the estuary, roughly 190 river miles to the southwest. The geographic distribution of coho salmon in the Klamath Basin covers approximately 38 percent of the entire ESU. Thus, the conservation value of the designated critical habitat in the action area is important for the species.

The Lower Klamath River is not discussed here in the critical habitat section because it falls within the boundaries of the Yurok Tribe Reservation, and tribal lands are excluded from the critical habitat designation. Similarly, habitat above IGD is not discussed here because the current critical habitat designation includes accessible reaches of the mainstem only up to IGD.

11.3.1 Habitat Conditions in the Action Area

This section will address habitat conditions and factors affecting conditions for coho salmon within the west side of the action area, which includes the mainstem Klamath River to the Pacific Ocean and the major tributaries of the Klamath River between IGD and the Salmon River (inclusive).

11.3.1.1 Water Quality

Section 303(d) of the Clean Water Act requires States to identify water bodies that do not meet water quality objectives and are not supporting their designated beneficial uses. Much of the Klamath basin is currently listed as water-quality impaired under section 303(d) of the Clean Water Act (Table 11.3). As such, total maximum daily loads (TMDLs) have been developed by Oregon, California, and the U.S. Environmental Protection Agency (USEPA) for specific impaired water bodies, with the intent to protect and restore beneficial uses of water. TMDLs estimate a water body's capacity to assimilate pollutants without exceeding water quality standards and set limits on the amount of pollutants that can be added and still protect identified beneficial uses. Additional information regarding Oregon TMDLs can be found on the Oregon Department of Environmental Quality website (http://www.deq.state.or.us/WQ/TMDLs/klamath.htm) and California TMDLs on the North Coast Regional Water Quality Control Board (NCRWQCB) website (http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/index.shtml).

Table 11.3. Impaired water bodies within the action area.

Water Body	Water Temperature	Sedimentation	Organic Enrichment/Low Dissolved Oxygen	Nutrients
Klamath River (Oregon-California State line to IGD)	x		x	x
Klamath River (IGD to Scott River*)	x		x	x
Klamath River (Scott River to Trinity River**)	x		x	x
Klamath River (Trinity River to mouth)	x	x	x	x
Shasta River	x		x	
Scott River	x	x		
Salmon River	x			

*Selected minor tributaries that are impaired for sediment and sedimentation include Beaver, Cow, Deer, Hungry, and West Fork Beaver creeks (USEPA 2010)
**Minor tributaries that are impaired for sediment and sedimentation include China, Fort Golf, Grider, Portuguese, Thompson, and Walker creeks (USEPA 2010).

11.3.1.1.1 Water Temperature

Water temperatures in the Klamath Basin vary seasonally and by location. Downstream from IGD, water released from the Iron Gate Reservoir is 1 to 4.5 °F (2.5 °C) cooler in the spring and 3.6 to 18 °F (2 to10 °C) warmer in the summer and fall, as compared with modeled conditions without the dams (PacifiCorp 2004a, Dunsmoor and Huntington 2006, NCRWQCB 2010, Risley et al. 2012). Immediately downstream from IGD (RM 190.1), water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California 2009, 2010).

Farther downstream, water temperatures are more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Meteorological control of water temperatures result in increasing temperature with distance downstream from IGD. For example, daily average temperatures between June and September are approximately 1.8 to 7.2 °F (1 to 4 °C) higher near Seiad Valley (RM 129) than temperatures just downstream from the dam (Karuk Tribe of California 2009, 2010). By the Salmon River (RM 66), the effects of IGD on water temperature are significantly diminished. Downstream from the Salmon River, the influence of the dam on water temperature in the Klamath River is not discernible from the modeled data (PacifiCorp 2005, Dunsmoor and Huntington 2006, NCRWQCB 2010).

Downstream from the Salmon River (RM 66), summer water temperatures begin to decrease slightly with distance as coastal meteorology (i.e., fog and lower air temperatures) reduces longitudinal warming (Scheiff and Zedonis 2011) and cool water tributary inputs increase the overall flow volume in the river. However, the slight decrease in water temperatures in this reach is generally not sufficient to support cold-water fish habitat during summer months. Daily maximum summer water temperatures have been measured at values greater than 78.8 °F (26°C) just upstream from the confluence with the Trinity River (Weitchpec [RM 43.5]), decreasing to 76.1 °F (24.5 °C) near Turwar Creek (RM 5.8; Yurok Tribe Environmental Program 2005, Sinnott 2010).

11.3.1.1.2 Dissolved Oxygen

Based upon measurements collected immediately downstream from IGD, dissolved oxygen concentrations regularly fall below 8 mg/L (Karuk Tribe of California 2001, 2002, 2007, 2009). Continuous sonde data collected at other Klamath River locations downstream from IGD during the summers of 2004 to 2006 show that roughly 45 to 65 percent of measurements immediately downstream from the dam did not achieve 8 mg/L. Daily fluctuations of up to 2 mg/L measured in the Klamath River downstream from IGD (RM 190) have been attributed to daytime algal photosynthesis and nighttime bacterial respiration (Karuk Tribe of California 2002, 2003; Yurok Tribe Environmental Program 2005; NCRWQCB 2010). Farther downstream in the mainstem Klamath River near Seiad Valley (RM 129), dissolved oxygen concentrations are higher than the reach immediately downstream from IGD, but are variable with mean daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of approximately 10.5 mg/L, from June through November 2001 to 2002 and 2006 to 2009 (Karuk Tribe of California 2001, 2002, 2007, 2009).

Measured concentrations of dissolved oxygen in the mainstem Klamath River downstream from Seiad Valley (RM 129) continue to increase with increasing distance from IGD (Figure 11.1). Dissolved oxygen concentrations near Orleans (RM 59) continue to be variable, with typical daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of 11.5 mg/L from June through November, 2001 to 2002 and 2006 to 2009 (Karuk Tribe of California 2001, 2002, 2007, 2009; NCRWQCB 2010; Ward and Armstrong 2010). Farther downstream, near the confluence with the Trinity River (RM 43) and at the Turwar gage (RM 5.8), minimum dissolved oxygen concentrations below 8 mg/L have been observed for extended periods of time during late summer/early fall (Yurok Tribe Environmental Program 2005, Sinnott 2010, Asarian and Kann 2013).

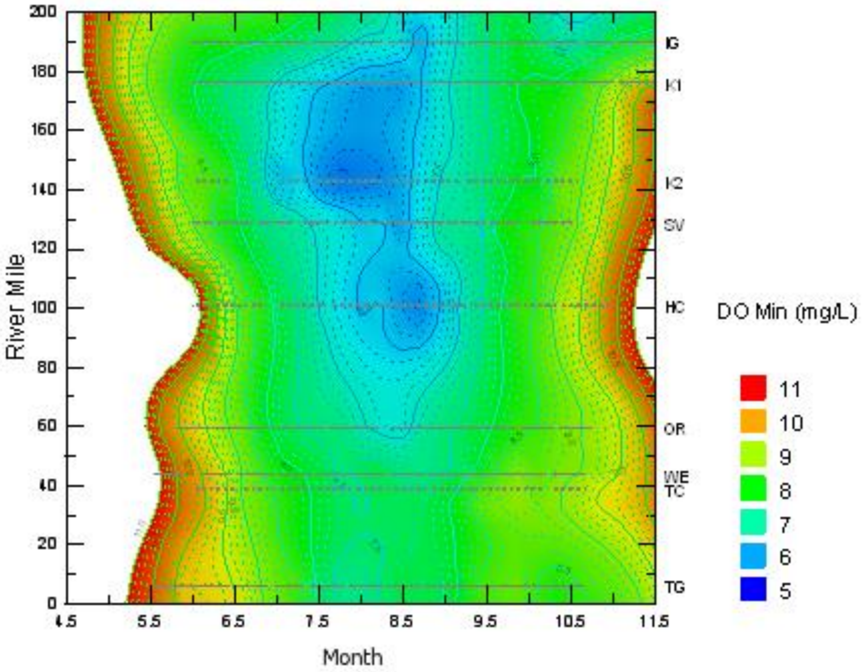

Figure 11.1 Longitudinal and seasonal patterns in average minimum dissolved oxygen concentrations for mainstem Klamath River sites in 2004-2005 (Asarian and Kann 2013). Horizontal grey lines are days with measurements and data outside the monitoring season are extrapolated.

11.3.1.1.3 Nutrients

Primary nutrients, including nitrogen and phosphorus, are affected by the geology of the surrounding watershed of the Klamath River, upland productivity and land uses, and a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. Nutrient and organic matter inputs from the Lost River Basin via Klamath Straits Drain and the Lost River Diversion Channel are also an important source of nutrients to the mainstem Klamath River.

Total phosphorus values typically range from 0.1 to 0.25 mg/L in the Klamath River between IGD and Seiad Valley (RM 129), with the highest values occurring just downstream from the dam. Total nitrogen concentrations in the river downstream from IGD generally range from <0.1 to over 2.0 mg/L, and are generally lower than those in upstream reaches due to reservoir retention and dilution by springs in the Klamath Hydroelectric Reach (Asarian et al. 2009). Further decreases in total nitrogen occur in the mainstem Klamath River due to a combination of tributary dilution and natural in-river nutrient removal processes such as uptake by aquatic plants and algae growing on the riverbed (periphyton). These processes strongly influence nitrogen concentrations in flowing rivers through removal processes such as denitrification and/or assimilation and storage related to biomass uptake (Asarian et al. 2010), or by late-seasonal recycling of nutrients downstream as active periphyton growth wanes. Ratios of nitrogen to phosphorus measured in the Klamath River downstream from IGD suggest the potential for nitrogen limitation of primary productivity with some periods of co-limitation by both nitrogen and phosphorus. However, concentrations of both nutrients are high enough that other factors (i.e., light, water velocity, or available substrate) are likely be more limiting to primary productivity than nutrients, particularly in the vicinity of IGD (FERC 2007, Asarian et al. 2010). This is particularly important with regard to factors controlling periphyton growth in this portion of the Klamath River.

Downstream from the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River due to tributary dilution and nutrient retention. Contemporary data (2005–2008) indicate that total phosphorus concentrations in this reach are generally 0.05–0.1 mg/L with peak values occurring in September and October. For total nitrogen, contemporary data indicate that on a seasonal basis this nutrient increases from May through November, with peak concentrations (<0.5 mg/L) typically observed during September and October. Both total phosphorus and total nitrogen are at or above the Hoopa Valley Tribe criteria of 0.2 mg/L total nitrogen and 0.035 mg/L total phosphorus (U.S. Department of the Interior (USDOI) and CDFW 2013).

Nutrient levels in the Klamath Estuary experience inter-annual and seasonal variability. Measured levels of total phosphorus in the estuary are typically below 0.1 mg/L during summer and fall (June to September), and total nitrogen levels are consistently below 0.6 mg/L (June–September; Sinnott 2011).

11.3.2 Upper Klamath River Reach

Critical habitat in the Upper Klamath River reach begins at the mouth of Portuguese Creek (RM 128) and extends upstream to IGD at RM 190. Water quality and quantity conditions reduce the functionality of essential habitat types in this reach and diminish the ability of the habitat types to establish essential features. IGD flow releases typically have a proportionally larger effect on the flow regime in this reach than in downstream reaches, because tributary accretions boost discharge farther downstream.

11.3.2.1 Juvenile Rearing Areas

Juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen levels, excessive nutrient loads, habitat loss, disease effects, pH fluctuations, non-recruitment of large woody debris, and loss of geomorphological processes that create habitat complexity. Water released from IGD during summer months is already at a temperature stressful to juvenile coho salmon, and solar warming can increase temperatures even higher (up to 26 ºC) as flows travel downstream (NRC 2004). Nocturnal dissolved oxygen levels directly below IGD are likely below 7.0 mg/L and highly stressful to coho salmon juveniles during much of the late summer and early fall. Between IGD and Seiad Valley (RM 129), daily maximum pH values in excess of 9.0 have been documented, as high primary production within the weakly buffered Klamath River basin causes wide diurnal pH fluctuations (PacifiCorp 2006). Riparian recruitment within the first several miles below IGD is likely impaired by the typically fast recession of the spring hydrograph, since the roots of newly established vegetation are unlikely to keep up with the rapidly lowering water table (FERC 2007). This can limit the amount of cover available to rearing coho salmon. IGD also impairs gravel and fine sediment recruitment downstream of the dam, which can result in poorly functioning floodplains that fail to support healthy riparian recruitment. Winter rearing areas suffer from minimal recruitment of large woody debris and stream habitat simplification. Many stream reaches within the Upper Klamath are either lacking riparian forest altogether or lack complex, late seral forest. Grazing and flow impairments along the mainstem and in tributaries such as Horse, Humbug, Willow, and Cottonwood creeks have severely degraded riparian function.

11.3.2.2 Juvenile Migration Corridor

In the Upper Klamath River reach, juvenile migration corridors are degraded because of diversion dams, low flow conditions, poorly functioning road/stream crossings, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. The unnatural and steep decline of the hydrograph in the spring likely slow the emigration of coho salmon smolts, speed the proliferation of fish diseases, and increase water temperatures more quickly than would occur otherwise. Disease effects, particularly in areas such as the Trees of Heaven site (RM 170), likely have a substantial impact on the survival of juvenile coho salmon in this stretch of river. Thus, the conservation role of the juvenile migration corridor of the Upper Klamath River reach is not properly functioning.

11.3.2.3 Adult Migration Corridor

The current physical and hydrologic conditions of the adult migration corridor in the Upper Klamath River reach are likely properly functioning in a manner that supports the conservation role of the adult migration corridor. Water quality is suitable for upstream adult migration, and with implementation of flows based on the RPA in NMFS' BiOp for Reclamation's Klamath Project (NMFS 2010a), flow volume is above the threshold at which physical barriers to migration are likely to form.

11.3.2.4 Spawning Areas.

Coho salmon are typically tributary spawners. However, low numbers of adult coho salmon annually spawn in the Upper Klamath River mainstem. Upstream dams block the transport of sediment into this reach of river. The lack of clean and loose gravel diminishes the amount and quality of salmonid spawning habitat downstream of dams. This condition is especially critical below IGD (FERC 2007). Water temperatures and water velocities are generally sufficient in this reach for successful adult coho salmon spawning. Gravel augmentation implemented under the PacifiCorp habitat conservation plan will partially restore spawning habitat in the Upper Klamath River reach, particularly between IGD and the confluence with the Shasta River.

Coho salmon spawning, which requires suitable substrate conditions, has been observed in Bogus, Horse, Beaver, Canyon, Grider and Seiad Creeks, as well as in small sections of the mainstem Upper Klamath River within the first several miles downstream of IGD. Downstream of IGD, channel conditions reflect the interruption of sediment flux from upstream by reservoir capture and the eventual re-supply of sediment from tributaries entering the mainstem Klamath River (PacifiCorp 2004). Upstream dams block the transport of sediment into this reach of river. The lack of clean and loose gravel diminishes the amount and quality of coho salmon spawning habitat on the mainstem downstream of IGD. However, as mentioned above, gravel augmentation implemented under the PacifiCorp habitat conservation plan will partially restore spawning habitat in the Upper Klamath River reach, particularly between IGD and the confluence with the Shasta River. Supply of spawning gravel can also be decreased in the Upper Klamath due to tributary blockage from poorly designed road crossings.

Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation. As part of a study investigating mainstem coho salmon spawning within the Klamath River, Magneson and Gough (2006) noted that the dominant substrate within sampled redds was either gravel or cobble, while a geomorphic and sediment evaluation of the Klamath River performed by Ayers Associates (1999) concluded that little fine sediment was embedded within river bed and bar gravel deposits. The effects of the curtailment of gravel recruitment in this reach of the river, includes decreased spawning habitat availability, competition for available spawning areas, crowding of eggs and embryos, and potentially decreased survival.

11.3.3 Middle Klamath River

The Middle Klamath River reach begins above the Trinity River confluence and extends upstream 85 miles to the mouth of Portuguese Creek (RM 128). This reach of the river is substantially different from the Klamath River upstream and downstream and adjacent sub-basins (Salmon and Scott rivers), particularly in precipitation and flow patterns (Williams et al. 2006). Water quality and quantity conditions impede the proper function of this river reach. IGD flow releases typically have a proportionally larger effect on the flow regime in this reach than the lower Klamath River reach, since two (Salmon and Trinity rivers) of the four major Klamath River tributaries enter near the lower end of this reach.

11.3.3.1 Juvenile Rearing Areas

Juvenile summer rearing areas in this stretch of river have been compromised relative to the historic state. A few tributaries within the Middle Klamath River Population (e.g., Boise, Red Cap and Indian Creeks) support populations of coho salmon (NMFS 2007), and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. However, these cool water tributary reaches can become inaccessible to juveniles when low flows and sediment accretion create passage barriers; therefore, summer rearing habitat can be limited. In general, mainstem habitat is not suitable for productive summer or winter rearing, making tributary habitats highly valuable for growth and survival of coho salmon. Generally, the conservation role of juvenile summer and winter rearing areas of the Middle Klamath River reach is impaired and functioning at a low level during summer months. NMFS (2010a) RPA flows are also allowing for enhanced fall flow variability which NMFS anticipates is providing transitory habitat in mainstem side-channels and margins preferred by juvenile coho salmon. Transitory habitat can provide suitable cover from predators and ideal feeding locations.

The PacifiCorp habitat conservation plan includes conservation actions with objectives to: (1) improve the quality and carrying capacity of thermal refugia along the Klamath mainstem downstream of IGD, (2) enhance coho salmon juvenile rearing habitat in the mainstem Klamath River corridor downstream of IGD, and (3) increase the abundance of large woody debris in the Klamath River downstream of IGD to contribute to the river's habitat elements and habitat forming features. Implementation of the habitat conservation plan conservation actions will improve juvenile rearing habitat quality on the mainstem.

11.3.3.2 Juvenile Migration Corridor

Disease effects in this stretch of river can limit the survival of juvenile coho salmon as they emigrate downstream. Low flows can slow the emigration of juvenile coho salmon, which can in turn lead to longer exposure times for disease, and greater risks due to predation. Flow releases in accordance with the NMFS (2010a) RPA will reduce juvenile transit time through areas of high disease infectivity as a result of increased flows below IGD. Higher velocities resulting from these flow releases are also expected to degrade the function and formation of slow "dead zones" within the channel that can harbor disease pathogens (Hardy et al. 2006), thereby reducing the overall impact of disease infection on coho salmon.

Refugia and off-channel rearing habitat are often cut off from mainstem and tributary streams from low flow conditions in the summer. Summer water diversions contribute to degraded habitat and/or fish passage issues in Stanshaw, Red Cap, Boise, Camp, Elk Creek, and Fort Goff creeks during low water years.

11.3.3.3 Adult Migration Corridor

NMFS believes that implementation of the NMFS (2010a) RPA flows alleviate many of the adult migration issues observed in the past and improve critical habitat in the Middle Klamath reach. Implementation of the NMFS (2010a) RPA fall and winter flow variability has alleviated instream conditions brought about by low flows that likely have resulted in impairments to upstream adult migration, concentration of high number of salmonids in holding habitat, and subsequent disease outbreaks in adults that can become lethal. NMFS expects that implementation of RPA flows creates habitat conditions suitable for adult migration in the Middle Klamath reach.

11.3.3.4 Spawning Areas.

There is some evidence that limited spawning of coho salmon occurs in the Middle Klamath River reach (Magneson and Gough 2006). However, the quality and amount of spawning habitat in the Middle Klamath River reach is naturally limited due to the geomorphology and the prevalence of bedrock in this stretch of river. Coho salmon are typically tributary and headwater stream spawners, so it's unclear if there was historically very much mainstem spawning in this reach.

11.3.4 Shasta River

11.3.4.1 Juvenile Rearing Areas

Juvenile rearing is currently confined to the mainstem Shasta River from RM 17 to RM 23, Big Springs Creek, Lower Parks Creek, Shasta River Canyon, Yreka Creek, and the upper Little Shasta River. Stream temperatures for summer rearing are poor throughout the mainstem Shasta River from its mouth to the Big Springs area (CDWR 1986). The onset of the irrigation season in the Shasta River watershed has a dramatic impact on discharge when large numbers of irrigators begin taking water simultaneously. This results in a rapid decrease in flows below the diversions, stranding coho salmon as channel margin and side channel habitat disappears (CDFG 1997) and in some extreme cases channels can become entirely de-watered (Klamath River Basin Fisheries Task Force 1991). Low stream flows can decrease rearing habitat availability for juvenile coho salmon.

Historically, the most vital habitat in the Shasta River basin were its cold springs, which created cold water refugia for juvenile coho salmon, decreased overall water temperatures, and allowed for successful summer rearing of individuals in natal and non-natal creeks and mainstem areas. These areas have been significantly adversely affected by water withdrawals, agricultural activities, and riparian vegetation removal. These land use changes have compromised juvenile rearing areas by creating low flow conditions, high water temperatures, insufficient dissolved oxygen levels, and excessive nutrient loads making the conservation value of juvenile rearing areas in the Shasta River not properly functioning. However, habitat restoration in the Big Springs complex and on TNC's Nelson Ranch have improved juvenile rearing conditions in those areas.

LWD is low in the Shasta River due to anthropogenic land use changes, including grazing and agricultural practices. Additionally, water diversions have likely lowered the water table throughout the basin, thereby limiting growth of riparian vegetation and channel forming wood. A river lacking large wood creates a deficit of shade and shelter, and decreases habitat complexity and pool volumes, all necessary components for over-summering juvenile survival.

11.3.4.2 Juvenile Migration Corridor

Juvenile migration corridors suffer from low flow conditions, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. Because there are significant water diversions and impoundments in the Shasta River, the unnatural and steep decline of the hydrograph in the spring likely slow the emigration of coho salmon smolts, and increase water temperatures more quickly than would occur otherwise. As such, the conservation value of the juvenile migration corridor is not properly functioning in the Shasta River.

In the spring of 2011 and 2012, the Montague Water Conservation District (MWCD), the largest water district in the Shasta Valley, released pulse flows from Dwinnell Dam to improve conditions for migrating juvenile salmonids in the reach between Dwinnell Dam and Parks Creek. Also in April 2013, The Nature Conservancy (TNC) entered into lease agreements with a few local ranchers and water districts, including the MWCD, to provide a pulse flow in the Shasta River to improve juvenile salmonid migration. These pulse flow events temporarily restored the conservation value of the Shasta River migration corridor, and provided juvenile coho salmon with favorable conditions to seek out ideal cold water summer habitats scattered throughout the upper Shasta River.

11.3.4.3 Adult Migration Corridor

The current physical and hydrologic conditions of the adult migration corridor in the Shasta River are likely properly functioning in a manner that supports the conservation role of the adult migration corridor. Water quality is suitable for upstream adult migration, and flow volume is above the threshold at which physical barriers are likely to form. Annually, persistent low flow conditions through October 1st, the end of the irrigation season, can also constrain the migration and distribution of spawning adult salmon.

11.3.4.4 Spawning Areas

The Shasta River in particular, with its cold flows and high productivity was once especially productive for anadromous fishes. The current distribution of spawners is limited to the mainstem Shasta River from RM 17 to RM 23, Big Springs Creek, lower Parks Creek, and the Shasta River Canyon. The reduction of LWD recruitment, channel margin degradation, and excessive sediment has limited the development of complex stream habitat necessary to sustain spawning habitat in the Shasta Valley. Persistent low flow conditions through the end of the irrigation season (October 1) can also constrain the timing and distribution of spawning adult coho salmon.

Coho salmon spawning has been observed in the Shasta River Canyon, lower Yreka Creek, throughout the Big Springs Complex area, and in Lower Parks Creek. Recent surveys have shown that channel conditions in the Shasta River mainstem and one of its most important tributary, Parks Creek, generally are poor and likely limit salmonid production. In some reaches, particularly in the lower canyon and the reach below the Dwinnell Dam, limited recruitment of coarse gravels is likely contributing to a decline in abundance of spawning gravels (Buer 1981). The causes of the decline in gravels include gravel trapping by Dwinnell Dam and other diversions, bank-stabilization efforts, and historical gravel mining in the channel. In a 1994 study of Shasta River gravel quality, Jong (1995) found that small sediment particles and fines (<4.75mm) were present in quantities associated with excessive salmon and steelhead egg mortality. Jong (1995) also concluded that gravel quality had deteriorated since 1980 when the DWR performed similar work in the Shasta basin. Greenhorn dam blocks the movement of gravel down Yreka Creek, and alters the Yreka Creek hydrograph.

11.3.5 Scott River

11.3.5.1 Juvenile Rearing Areas

Numerous water diversions, dams and interconnected groundwater extraction for agricultural purposes, and the diking and leveeing of the mainstem Scott River have reduced summer and winter rearing habitat in the Scott River basin, limiting juvenile survival. Although rearing habitat still exists in some tributaries, access to some of these areas is hindered by dams and diversions, the existence of alluvial sills, and the formation of thermal barriers at the confluence of tributaries. Where passage is possible, there are thermal refugial pools and tributaries where the water temperature is several degrees cooler than the surrounding temperature, providing a limited amount of rearing habitat in the basin.

Currently, valley-wide agricultural water withdrawals and diversions, groundwater extraction, and drought have all combined to cause premature surface flow disconnection along the mainstem Scott River. In addition, summer discharge has continued to decrease significantly over time, further exacerbating detrimental effects on coho salmon in the basin. These conditions restrict or exclude available rearing habitat, elevate water temperature, decrease fitness and survival of over-summering juveniles, and sometimes result in juvenile fish strandings and death. The conservation value of juvenile rearing areas is not properly functioning in the Scott River.

Since 2007, the Scott River Water Trust has leased water from willing water right holders along tributaries that drain the west side of the valley during the late summer months when many of these tributaries have very little surface flow. These water leases allow the tributaries to remain connected and have improved conditions for juvenile rearing during the summer.

Woody debris is scarce throughout the mainstem Scott River and its tributaries. Mainstem habitat has been straightened, leveed, and armored. Anthropogenic impacts have resulted in a lack of channel complexity from channel straightening and reduced amounts of woody material (Cramer Fish Sciences 2010). The present-day mainstem Scott River bears minor resemblance to its more complex historic form although meandering channel planforms are still present (Cramer Fish Sciences 2010). The cumulative effect of these changes cannot be quantified. However, both the amount and quality of habitat has been clearly reduced. Large woody debris that is available along the mainstem corridor is highly mobile during high flow events, further decreasing retention of large woody that does get recruited. Recent data regarding large woody debris in tributaries indicates that recruitment is improving in the uplands, providing more complex habitat and potential rearing areas in stream reaches above the valley.

11.3.5.2 Juvenile Migration Corridor

Physical fish barriers exist in the Scott River watershed. For instance, Big Mill Creek, a tributary to the East Fork Scott River, has a complete fish passage barrier caused by down cutting at a road culvert outfall (CalFish 2011). For many years, the City of Etna's municipal water diversion dam on Etna Creek effectively blocked fish passage into upper Etna Creek, however this dam was retrofitted with a volitional fishway in 2010.

In addition, valley-wide agricultural water withdrawals and diversions, groundwater extraction, and natural cycles of drought have all combined to cause premature surface flow disconnection along the mainstem Scott River. These conditions can consistently result in restrictions or exclusions to suitable rearing habitat, contribute to elevated water temperatures, and contribute to conditions which cause juvenile fish stranding and mortality. Although rearing habitat still exists in some tributaries, access to and from these areas is hindered by dams and diversions, the existence of alluvial sills, and the formation of thermal barriers at the confluence of tributaries and stagnant, disconnected pools. Where low flows have not restricted juvenile movements, there are thermal refugial pools and tributaries available where water temperatures are suitable for growth and survival, providing a limited amount of rearing habitat in the basin. Therefore, the conservation value of the juvenile migration corridor is not properly functioning in the Scott River. In dry water years, the Scott River Water Trust has obtained water leases to improve migration flows for adult salmon during the fall, which has improved the migration corridor for coho salmon in recent years.

11.3.5.3 Adult Migration Corridor

The current physical and hydrologic conditions of the adult migration corridor in the Scott River reach are likely properly functioning in a manner that supports its conservation role of the adult migration corridor. Water quality is suitable for upstream adult migration, and flow volume is above the threshold at which physical barriers are likely to form.

11.3.5.4 Spawning Areas

Spawning activity and redds have been observed in the East Fork Scott River, South Fork Scott River, Sugar, French, Miners, Etna, Kidder, Patterson, Shackleford, Mill, Canyon, Kelsey, Tompkins, and Scott Bar Mill Creeks. Other than the two anthropogenic barriers on Etna Creek and the mainstem Scott River, gravel transport in the Scott River Valley basin is unimpeded. Pebble count data and survey data indicate that suitable gravels sizes are found in conjunction with slopes also suitable for spawning (Cramer Fish Sciences 2010). These observations suggest that the amount of coarse sediment and its rate of delivery are not limiting spawning habitat availability in the Scott River Watershed.

Although gravel mobilization is unimpeded, historic land uses create a legacy of effects that are continuing to impact available spawning habitat. Data shows that spawning substrate is largely suitable throughout the basin, but the spatial extent of these areas is limited due to mine tailing piles and other legacy mining effects. Current conditions in the Scott River mimic hydraulic conditions similar to bedrock canyons where sediment used by salmonids has a lower likelihood of persistence due to increased (or more efficient) sediment transport compared to unconfined reaches (Cramer Fish Sciences 2010). The over extraction of streambed alluvium likely also have stripped the alluvial cover from some river reaches exposing underlying bedrock, the net result of which is enhanced sediment transport, less persistent alluvium, and an overall loss of physical complexity (Cramer Fish Sciences 2010). Channel confinement by historic mining tailings indirectly affects the diversity of stream habitat that might otherwise be available. Many of these tailing piles are too large for the adjacent watercourse to reshape.

11.3.6 Salmon River

11.3.6.1 Juvenile Rearing Areas

According to available juvenile fish survey information beginning in 2002, juvenile coho salmon have been found rearing in most of the available tributary habitat with moderate or high IP values. These streams are tributaries to the South Fork Salmon (Knownothing and Methodist Creek), at least nine tributaries to the North Fork Salmon, and in mainstem Salmon River tributaries (Nordheimer and Butler Creeks; SRRC 2008). The lower reaches of these tributaries provide substantially cooler summer habitat than mainstem river habitat. Current data only includes presence/absence information. However, there is some indication that juvenile coho salmon move up from the mainstem Klamath River into the cooler Salmon River tributaries during summer months when stressed by mainstem water temperatures (USFS 2009). Some of juveniles found in surveys are thought to reflect non-natal as well as natal rearing.

The coho salmon juvenile life stage is likely the most limited because quality summer and winter rearing habitat is impaired for the population. Even though summer water temperatures are cooler than the mainstem Klamath River, juvenile summer rearing habitat is impaired by high temperatures with few accessible thermal refugia areas. Water temperature is one of the most important limiting factors along with floodplain and channel structure, both of which influence the quantity and quality of rearing habitat in the Salmon River and the access and availability of thermal refugia. Winter off-channel rearing habitat is naturally low in the area, and therefore many juveniles are likely to be forced downstream where they may rear in the estuary or in off-channel habitat in the mainstem (NMFS 2007). The conservation value of juvenile rearing areas is not properly functioning in the Salmon River.

11.3.6.2 Juvenile Migration Corridor

Juvenile migration corridors suffer from high water temperatures during the summer and approximately 13 migration barriers at road crossings. Therefore, the conservation value of the juvenile migration corridor is impaired in the Salmon River.

11.3.6.3 Adult Migration Corridor

The current physical and hydrologic conditions of the adult migration corridor in the Scott River reach are likely properly functioning in a manner that supports its conservation role of the adult migration corridor. Water quality is suitable for upstream adult migration, and flow volume is above the threshold at which physical barriers are likely to form.

11.3.6.4 Spawning Areas

Known coho salmon spawning has been observed in the Nordheimer Creek, Logan Gulch, Brazil Flat, and Forks of Salmon areas along the mainstem Salmon River, in the Knownothing and Methodist Creek reaches of the South Fork Salmon River, and in the lower North Fork Salmon River (SRRC 2007, SRRC 2010a). The total linear stream distance used by spawning coho salmon from 2004 to 2010 is at least 8 km of surveyed stream habitat (NMFS 2012b).

11.3.7 Summary of Critical Habitat in Interior-Klamath Diversity Stratum

The current function of critical habitat in the Interior-Klamath Diversity Stratum is degraded relative to its unimpaired state. Sedimentation, low stream flows, poor water quality, stream habitat simplification, and habitat loss from poorly designed road crossings plague coho salmon streams in this stratum. Additionally, critical habitat in the Interior Diversity stratum often lacks the ability to establish essential features due to ongoing human activities. Water use in many regions throughout the diversity stratum (e.g., Shasta and Scott rivers) reduces summer base flows, which limits the establishment of several essential features such as water quantity and water quality.

11.3.8 Factors Affecting Coho Salmon Critical Habitat in the Action Area

11.3.8.1 Reclamation's Klamath Project

11.3.8.1.1 Hydrologic Alteration

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.) authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of water for the reclamation of arid and semiarid lands in the western States. Congress facilitated development of the Klamath Project by authorizing the Secretary to raise or lower the level of Lower Klamath and Tule Lakes and to dispose of the land uncovered by such operation for use under the Reclamation Act of 1902. The Oregon and California legislatures passed legislation for certain aspects of the Klamath Project, and the Secretary of the Interior authorized construction May 15, 1905, in accordance with the Reclamation Act of 1902 (Act of February 9, 1905, Ch. 567, 33 Stat. 714). The Project was authorized to drain and reclaim lakebed lands in Lower Klamath and Tule Lakes, to store water of the Upper Klamath and Lost Rivers, including water in the Lower Klamath and Tule Lakes, to divert and deliver supplies for Project purposes, and to control flooding of the reclaimed lands.

Starting around 1912, construction and operation of the numerous facilities associated with Reclamation's Klamath Project significantly altered the natural hydrographs of the upper and lower Klamath River. In 1922, the level of Upper Klamath Lake was raised by the Link River dam. Reclamation's Klamath Project now consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 200,000 ac (81,000 ha) of irrigated farmlands in the upper Klamath Basin (Reclamation 2012).

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations. The authors concluded that the timing of peak and base flows changed significantly after construction of the Project, and that the operation increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gage sites. Their report also noted that water diversions also occur in areas outside the Project boundaries. IGD was completed in 1962 to re-regulate flow releases from the Copco facilities. However, IGD did not restore the pre-Project hydrograph. Rather, base flows were altered. Fall flows were slightly increased while spring and summer flows were substantially reduced. The modeled data for Iron Gate, California, clearly shows a decrease in the magnitude of peak flows, a 2-month shift in timing of flow minimums from September to July, as well as reduction in the amount of discharge in the summer months. By truncating the range of flows that led to diverse coho salmon life history strategies, changes in the annual hydrology likely adversely affected coho salmon populations.

Although monthly flow values can be useful for general river-basin planning, they are not useful for ecological modeling for river habitats because monthly average flows mask important flow variability that likely exist only for a few days or less (NRC 2008). In order to address this shortcoming in analyzing monthly flow data, Figure 11.2 is presented to examine daily historical and current Klamath River discharge patterns at Keno, Oregon.

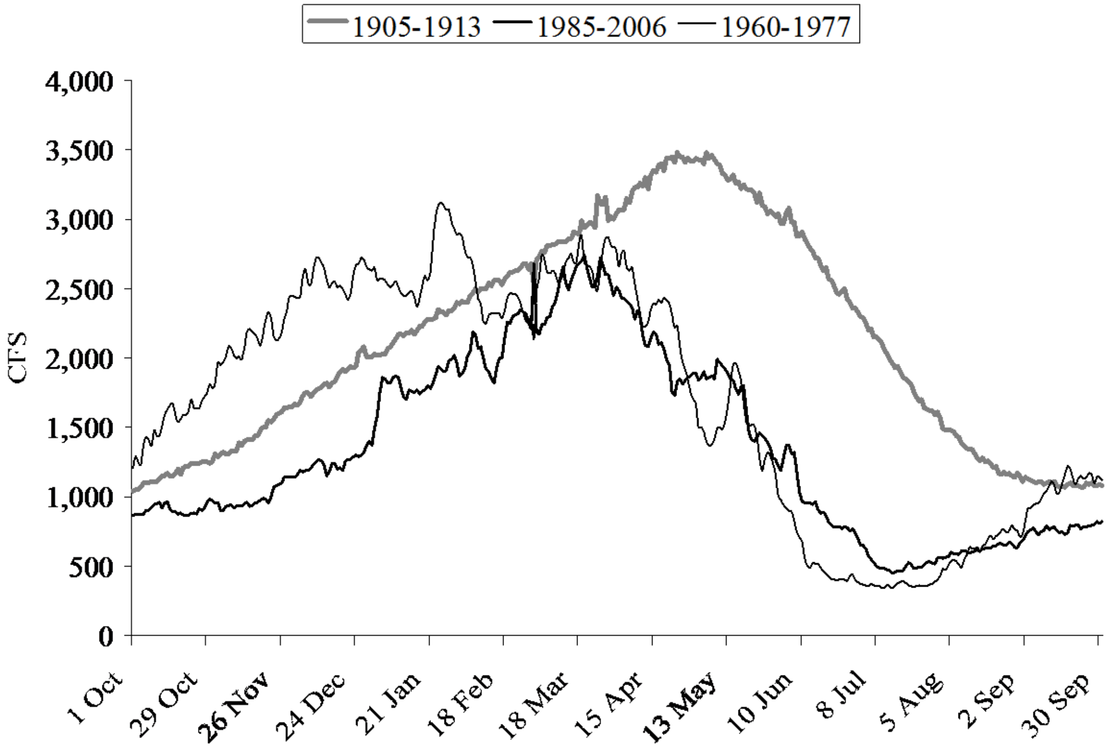

Figure 11.2. Average daily Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired riverflow, while two more modern time periods represent discharge after implementation of the Project.

Data in Figure 11.2 are averages of daily discharge across years for three different time periods. The 1905 to 1913 period represents historical unimpaired flows in the Klamath River at Keno, OR. However, diversions to the A Canal of Reclamation’s Klamath Project began in 1906, so the 1905 to 1913 period does not represent completely unimpaired flow, rather the closest approximation to unimpaired flows. Two more modern periods, 1960 to 1977 and 1985 to 2006, can provide some insight into the effects of Reclamation’s Klamath Project. These time periods were chosen because the climatic patterns cycled through a cool phase (increased snowpack and streamflow) from the mid-1940s to 1976 and through a warm phase (decreased snowpack and streamflow) from 1977 through at least the late 1990s (Minobe 1997, Mote 2006). By using these two time periods, the effects of Reclamation's Klamath Project may be examined under relatively wet (1960 to 1977) and relatively dry (1985 to 2006) climate conditions.

Data presented in Figure 11.2 show that, regardless of climate conditions, there has been a shift in both the magnitude and timing of average peak flows in the Klamath River at Keno, Oregon. The average peak flow has declined from approximately 3,400 cfs (96.3 m^3/sec) in the 1905 to 1913 period to approximately 2,700 cfs (76.5 m^3/sec) in the period after 1960. The timing of the average peak for these periods has shifted from late April or early May to mid- to late-March, a significant shift of more than one month. Additionally, there is far less flow during the spring and summer in the period since 1960 than during the early 1900s.

Altered flows likely interfere with environmental cues that initiate distribution of juvenile coho salmon in the river, alter seaward migration timing, and potentially impact other important ecological functions, leaving juveniles exposed to a range of poor-quality habitat and prolonged exposure to stressful over-wintering and summer rearing conditions (NMFS 2010a). Historically, river discharge did not reach base (minimum) flow until September. After implementation of Reclamation's Klamath Project and factoring other off-Project diversions, minimum flows for the year now occur in the beginning of July, which is a shift in base flow minimum of approximately two months earlier. These altered flows likely also reduce the amount of rearing habitat available. Additionally, off-channel habitat along the mainstem Klamath River has been significantly reduced due to the lack of variable flows that would otherwise inundate floodplains and side channels, creating important rearing habitat (NMFS 2010a).

11.3.8.1.2 Project Water Consumption

During the 1981 to 2011 POR, the median Project delivery from all sources by water year is 428,416 acre-ft with a minimum of 132,105 acre-ft and a maximum of 498,197 acre-ft (Cameron 2013). Deliveries of irrigation water to the Klamath Project from UKL are trending upward during the period of record (Figure 11.3), and water demands increase in dry years (Mayer 2008). While the trends suggest increases in Project deliveries when considered in isolation, they may also be examined with respect to other water-related trends in the upper Klamath Basin. As described below, average annual air temperature in the upper Klamath Basin has been increasing over several decades, snow water equivalent has been declining, and both these trends are predicted to get worse. In addition, annual net inflow to UKL has been declining over the period of record and the trend is statistically significant (see *Upper Klamath Lake Tributaries Water Quality* section of this BiOp; Mayer and Naman 2011). Therefore, the increase in Project deliveries is likely to be caused by changes in irrigation and cropping patterns, additional land under irrigation, decadal shifts in weather, global climate change, conjunctive uses of surface water and groundwater, or a combination of factors.

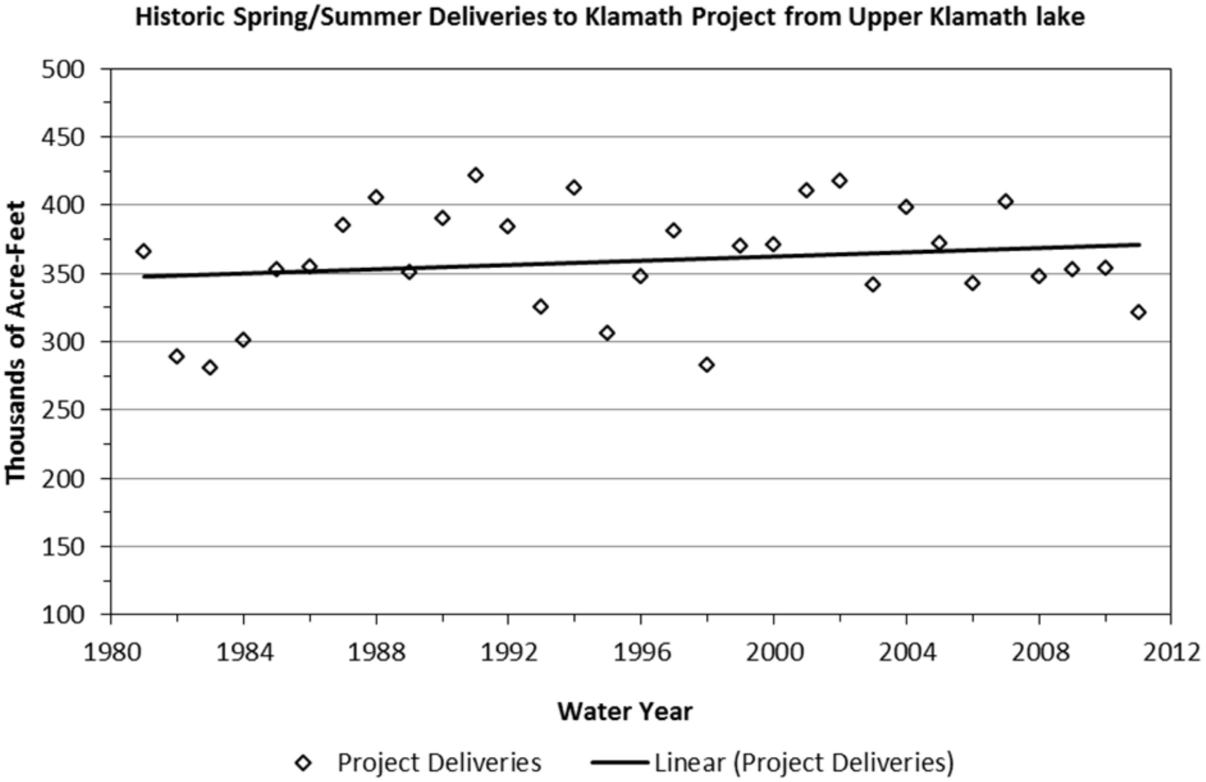

Figure 11.3. Historic April through November deliveries to Project from Upper Klamath Lake.

11.3.8.2 Agriculture

Crop cultivation and livestock grazing in the upper Klamath Basin began in the mid-1850s. Since then, valleys have been cleared of brush and trees to provide more farm land. By the late 1800s, some native perennial grasses were replaced by non-native species. This, combined with soil compaction, resulted in higher surface erosion and greater peak water flows in streams. Other annual and perennial crops cultivated included grains, alfalfa hay, potatoes and corn.

Besides irrigation associated with Reclamation's Klamath Project, other non-Project irrigators operate within the Klamath River Basin. Irrigated agriculture both above (e.g., Williamson, Sprague, and Wood rivers) and surrounding UKL consists of approximately 180,000 acres. Excluding Reclamation's Project, estimated average consumptive use in the upper Klamath Basin is approximately 350,000 acre feet per year (NRC 2004). Irrigated agricultural land in the Shasta River and Scott River valleys consist of approximately 51,600 acres and 33,000 acres, respectively (Reclamation 2009). Estimated consumptive use of irrigation water by crops in the Shasta and Scott River valleys is approximately 100,000 and 71,000 acre-feet per year, respectively.

Actual diversions would exceed the consumptive use of the crops due to irrigation application methods, conveyance losses in the system and surface evaporation. Current agricultural development in the Scott River Valley, which has increased significantly since the 1970s, consists of approximately 29,000 acres of irrigated land with an estimated annual irrigation withdrawal of approximately 81,070 acre feet per year (Van Kirk and Naman 2008). Agricultural diversions in both the Shasta and Scott rivers in some years, especially dry water years, can virtually dewater sections of these rivers, impacting coho salmon within these streams as well as those in the Klamath River.

There are two other diversion systems within the Klamath River Basin that affect the action area for purposes of NMFS' BiOp. Fourmile Creek and Jenny Creek diversions transfer water from the Klamath River Basin into the Rogue River Basin. Estimated annual (1960 to 1996) out of basin diversions from the Fourmile Creek drainage of the Klamath River basin to the Rogue River Basin was approximately 4,845 acre-feet. Net out of basin diversions from the Jenny Creek drainage of the Klamath River Basin to the Rogue River Basin were approximately 22,128 acre-feet (38,620 acre-feet exported - 16,492 acre-feet imported). Thus the total average annual (1960 to 1996) diversions from the Klamath River Basin to the Rogue River Basin was 26,973 acre-feet (La Marche 2001).

As the value of farm lands increased throughout the Klamath River Basin, flood control measures were implemented. During the 1930s, the U.S. Army Corps of Engineers implemented flood control measures in the Scott River Valley by removing riparian vegetation and building dikes to constrain the stream channel. As a result of building these dykes (banking), the river became more channeled, water velocities increased, and the rate of bank erosion accelerated. To minimize damage, the Soil Conservation Service (now known as NRCS) in Siskiyou County planted willows along the stream-bank and recommended channel modifications take place which re-shaped the stream channel into a series of gentle curves. The effectiveness of these actions has not yet been measured.

There has been a recent decline in UKL outflows since the 1960s, which is likely due to increasing diversions, decreasing net inflows, or other factors (Mayer 2008). There have been declines in winter precipitation in the upper Klamath Basin in recent decades and declines in upper-Klamath Lake inflow and tributary inflow, particularly base flows (Mayer 2008). Declines in tributary base flow could be due to increase consumptive use, in particular, groundwater use, and/or climate changes. Agricultural diversions from the lake have increased over the 1961 to 2007 period, particularly during dry years (Mayer 2008). Declines in Link River flows and Klamath River at Keno flows in the last 40-50 years have been most pronounced during the base flow season (Mayer 2008), the time when agricultural demands are the greatest.

Consumptive use of water is expected to negatively impact one or more of the VSP criteria for the interior Klamath populations because it reduces summer and fall discharge of tributaries that the populations use (Van Kirk and Naman 2008); and low flows in the summer have been cited as limiting coho salmon survival in the Klamath Basin (CDFG 2002a; NRC 2004). Specifically, the spatial structure, population abundance, and productivity can be impacted by agricultural activities. Altered flows likely interfere with environmental cues that initiate distribution of juvenile coho salmon in the river, alter seaward migration timing, and potentially impact other important ecological functions, leaving juveniles exposed to a range of poor quality habitat, and prolonged exposure to stressful over wintering and summer rearing conditions (NMFS 2010a).

11.3.8.3 Klamath Hydroelectric Settlement Agreement

Beginning in 2005, negotiations by a diverse group of stakeholders, including federal agencies, the States of California and Oregon, Indian tribes, counties, agricultural organizations, and conservation and fishing groups led to the Klamath Hydroelectric Settlement Agreement (KHSA) and the associated Klamath Basin Restoration Agreement (KBRA). Both the KHSA and KBRA were signed in February 2010[5]. The KHSA provides a process for the Secretary of the Interior to make a determination (Secretarial Determination) whether removal of the Four Facilities on the Klamath River (i.e., Iron Gate, Copco 1 and 2, and J.C. Boyle dams) will 1) advance restoration of the salmonid fisheries of the Klamath Basin, and 2) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes. The KHSA provides for the abeyance of the FERC relicensing process pending the outcome of the Secretarial Determination and other contingencies related to removal of the Four Facilities. If the Secretarial Determination is affirmative, then removal of the Four Facilities is expected to proceed in 2020.

In November 2012, the Services prepared a preliminary BiOp on the prospective action of removing the Four Facilities on the Klamath River (NMFS and USFWS 2012). The Services did not analyze the effects of the KBRA in the preliminary BiOp because details on the KBRA programs were not sufficient for the Services to assess their impacts on listed species at that time. The KHSA requires certain conditions to be met before the Secretarial Determination is made, including enactment of Federal authorizing legislation. Currently, Federal authorizing legislation has not been enacted for the KHSA and KBRA. The Services will finalize the BiOp on the removal of the Four Facilities at the appropriate time if the preconditions for a Secretarial Determination are met and the Secretarial Determination is affirmative.

11.3.8.4 PacifiCorp Habitat Conservation Plan

Covered activities under the PacifiCorp habitat conservation plan (HCP) and associated incidental take permit under ESA section 11(a)(1)(B) include activities that are necessary to operate and maintain the Klamath hydroelectric facilities during the next nine years prior to the removal of these hydroelectric facilities if the Secretarial Determination under the KHSA is affirmative, or prior to implementation of mandatory fishways that would be required under any new license for the Klamath Hydroelectric Project if the Secretarial Determination is negative or the Klamath Hydroelectric Settlement Agreement is terminated for any other reason. Hydroelectric generation is the primary activity conducted at Klamath Hydroelectric Project facilities, with the exception of the Keno development, which does not include power-generating equipment. Many of these activities are governed by the existing FERC license or agreements with other entities (e.g., Reclamation), or through voluntary commitments from PacifiCorp. Detailed information on habitat conservation plan’s covered activities can be found in Chapter 2 of the PacifiCorp habitat conservation plan (PacifiCorp 2012a).

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[5] Note that the Federal agencies did not sign the KBRA.

The PacifiCorp habitat conservation plan includes measures that comprise the coho salmon conservation program, which includes the following:

- Implementation of turbine venting at IGD to enhance dissolved oxygen concentrations in surface waters downstream of IGD;
- Implementation of measures to provide instream flow, flow variability, and flow ramping rate measures to benefit listed coho salmon downstream of IGD consistent with NMFS's BiOp for Reclamation's Klamath Project (NMFS 2010a);
- Retrieving large woody debris trapped at or near the Four Facilities (Iron Gate, Copco 1 and 2, and J.C. Boyle) and placing it in mainstem or tributary waters downstream of IGD;
- Habitat restoration projects designed to enhance the survival and recovery of listed coho salmon, funded through the coho enhancement fund, and conducted by third parties;
- Research studies on fish disease conditions and causal factors downstream of IGD, funded through the Klamath River fish disease research fund, and conducted by third parties; and
- Funding and participation in IGH measures developed to support a Hatchery and Genetic Management Plan (HGMP) to maximize conservation benefits of the hatchery program to coho salmon.

Turbine venting at IGD is likely improving dissolved oxygen immediately downstream of IGD. PacifiCorp has implemented turbine venting on a trial basis beginning in 2009, and turbine venting testing in combination with a forced air blower (fall 2010) demonstrated that dissolved oxygen saturation rose by 14.9 percentage points (a 29 percent increase) and average dissolved oxygen concentration rose by 1.81 mg/L (a 33 percent increase) during venting treatment as compared to no treatment (PacifiCorp 2011b). If dissolved oxygen is increased, higher nighttime dissolved oxygen concentrations are likely to increase juvenile coho salmon foraging opportunities outside the confines of the existing thermal refugia areas, potentially resulting in higher survival rates for juvenile coho salmon that rear within a six mile reach from IGD each summer.

Restoration actions implemented under the coho salmon conservation strategy throughout the duration of the ESA section 11(a)(1)(B) permit are expected to increase over-summer survival for juvenile coho salmon. Projects that create, maintain, or improve access by coho salmon to habitats downstream of IGD are expected to increase the distribution of coho salmon and improve the spatial structure of the population. Increasing available habitat below IGD will help ensure that coho salmon populations remain stable and improve while parallel actions are taken to address volitional fish passage issues in the longer term.

The PacifiCorp HCP has two conservation targets for refugia: (1) Improve habitat cover and complexity (by about 30 to 50 percent of the total existing cover) or maintain habitat cover and complexity (if already suitable) at 28 cold water refugia sites along the mainstem Klamath River, and (2) Increase the extent and/or duration (by about 30 to 50 percent of the total existing extent and/or duration) of nine cold water refugia sites along the mainstem Klamath River. Successful implementation of these targets is expected to benefit the conservation of the Klamath River coho populations. Protection of the very limited thermal refugia sites in the Klamath River mainstem should help improve juvenile-to-smolt survival rates which likely aid in improving viability for coho salmon and other salmonids during the ESA section 11(a)(1)(B) permit duration (NMFS 2012b).

PacifiCorp will actively participate in a flow variability team that will develop fall and winter and spring flows. Fall and winter flows will be designed to redistribute spawned-out adult salmonid carcasses which likely are concentrated in the upper basin causing the potential for disease outbreaks to occur, and will also be designed to scour channel bottom fine sediment and organic matter. These actions will help reduce the prevalence of *P. minibicornis* and *C. shasta*, the organisms tied to health related impacts on coho. Increased spring flows are expected to aid in maintaining or expanding summer rearing habitat for juveniles occupying the Upper Klamath reach. Based on analyses presented in NMFS (2010a), NMFS concludes that the availability of rearing habitat will increase with PacifiCorp's cooperation in implementing RPA flows and increase juvenile survival though the smolt stage. Spring flow objectives will also include timing release of flows to reduce smolt transit time through disease prone areas. The relationship between increasing discharge and faster smolt migration has been identified for salmonid species in other regulated rivers (Berggren and Filardo 1993, Giorgi et al. 1997). Increased migration speed likely also reduces exposure time to predators, thereby improving smolt survival (NMFS 2012b).

The augmentation of gravel in the river downstream from IGD will partially restore conditions for coho salmon spawning in the river during fall. Properly functioning spawning substrate provides ample interstitial flow through redds, and is of suitable size to permit efficient redd excavation by spawning adults. Effective salmon spawning has been observed downstream of other dams, where suitable substrate has been present (Giorgi 1992, Geist and Dauble 1998). NMFS expects the same potential to be realized below IGD. The Project-related effects on gravel, and the concomitant benefits of gravel augmentation, are expected to be largely restricted to the uppermost several miles of the Upper Klamath reach below IGD. As such, gravel augmentation is not expected to substantively alter conditions further downstream in the Middle Klamath and Lower Klamath reaches. In the Sacramento-San Joaquin River system, gravel augmentation is a common practice, and researchers there have observed increased spawner use of the new gravel supplied by gravel augmentation (Merz and Chan 2005, Cummins et al. 2008). Overall, NMFS expects that implementation of the gravel augmentation measures will improve the functionality and conservation value of critical habitat for adult spawning below IGD as compared to current conditions (NMFS 2012b).

The quarterly augmentation of LWD recruitment to the Upper Klamath reach will add to the habitat complexity below IGD, resulting in improvements to the conservation value of critical habitat for rearing juveniles. The transport of trapped LWD on a quarterly basis either to the Klamath mainstem directly or for use in constructed habitat features, will improve habitat complexity or, in some cases, provide localized thermal refugia in the form of shade. Both of these habitat features enhance survival of juvenile coho by affording protection from predators and cooling water during critical periods in the late summer and fall. NMFS believes the quarterly transport of the expected small amount of LWD trapped by PacifiCorp reservoirs to areas downstream of IGD, or to be reserved for the construction of habitat enhancement projects (e.g., complex wood jam structures), will not result in adverse effects to juvenile and smolt migration corridors as the interruption is a relatively short duration. Once placed downstream of

IGD, or used in constructed habitat projects, the LWD will begin providing benefits to coho salmon and its rearing habitat.

11.3.8.5 Timber Harvest

Timber harvesting in the action area has had a long-lasting effect on fish habitat conditions. Most notably, harvest of streamside trees during the early and middle 1900s has left a legacy of reduced large woody debris recruitment and contributed to elevated stream temperatures, particularly along the Klamath mainstem and along the lower reaches of the Scott River. However, Reclamation's Klamath Project plays a significant role in elevating water temperatures in the Klamath mainstem (NRC 2004). Sedimentation from modern-day harvest units, harvest-related landslides and an extensive road network continues to impact habitat although at much reduced levels as compared to early logging. Ground disturbance, compaction, and vegetation removal during timber harvest has modified drainage patterns and surface runoff resulting in increased peak storm flows which has increased occurrences of channel simplification and channel aggradation. Simplification of stream channels and sediment aggradation results in loss or destruction of salmonid habitat as pool complexes and side channel winter rearing habitat are often lost or degraded to such an extent as to no longer provide refugia for developing juveniles.

In order to combat the severe alteration of salmon habitat caused by historical forest practices, several forest practices and management plans have been enacted in the Klamath basin. The Northwest Forest Plan (NFP) is an integrated, comprehensive design for ecosystem management, intergovernmental and public collaboration, and rural community economic assistance for federal forests in western Oregon, Washington, and northern California. Since adoption of the NFP in 1994, timber harvest and road building on Forest Service lands in the Klamath basin have decreased dramatically and road decommissioning has increased. It is expected that implementation of the NFP will help to recover aquatic habitat conditions adversely affected by legacy timber practices.

Along the lower Klamath River, Green Diamond Resource Company owns and manages approximately 265 square miles of lands below the Trinity River confluence for timber production. The company has completed an habitat conservation plan for aquatic species, including SONCC ESU coho salmon, and NMFS issued an ESA section 11(a)(1)(B) incidental take permit on June 12, 2007. The 50-year habitat conservation plan commits Green Diamond to combating sediment production from approximately half of its high- and moderate-priority road sites, property-wide, over the first 15 years of implementation as well as places restrictions on timber harvest on unstable slopes and in fish-bearing watercourses. The habitat conservation plan is expected to reduce over time the impacts of Green Diamond's timber operations on aquatic species habitat.

11.3.8.6 Restoration

There are various restoration and recovery actions underway in the Klamath Basin aimed at removing barriers to salmonid habitat and improving habitat and water quality conditions for anadromous salmonids. Congress authorized $1 million annually from 1986 through 2006 to implement the Klamath River Basin Conservation Area Restoration Program. The Klamath

River Basin Fisheries Task Force (Task Force) was established by the Klamath River Basin Fishery Resources Restoration Act of 1986 (Klamath Act) to provide recommendations to the Secretary of the Interior on the formulation, establishment, and implementation of a 20-year program to restore anadromous fish populations in the Klamath River Basin to optimal levels. The 16-member Task Force included representatives from the fishing community, county, state and federal agencies, and tribes. A Technical Work Group of the Task Force provided technical and scientific input. In 1991, the Task Force developed the Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program to help direct fishery restoration programs and projects throughout the Klamath River.

In addition to creating a fishery restoration plan for the river basin restoration program, the Task Force also encouraged local watershed groups to develop restoration plans for each of the five sub-basins of the lower Klamath River Basin. These groups included the Shasta River Coordinated Resource Management Planning Group (Shasta sub-basin), Scott River Watershed Council (Scott sub-basin), Salmon River Restoration Council (Salmon sub-basin), Karuk Tribe and Mid-Klamath Watershed Council (mid-Klamath sub-basin), and the Yurok Tribe (lower-Klamath sub-basin). Since 1991, over $1.3 million has been given to these groups to develop the sub-basin plans and conduct restoration activities. Funds from the Klamath Act are often leveraged to develop broader restoration programs and projects in conjunction with other funding sources, including CDFW restoration grants. As an example, nearly $1.9 million of CDFW restoration funding was spent on a variety of Klamath River Basin restoration projects during the 2002 to 2006 period. While the Klamath River Basin Conservation Area Restoration Program ended in 2006, federal funds were authorized for fiscal year 2007, and the USFWS continues to administer funds in the near term consistent with the goals of the program.

In August, 2004, the California State Fish and Wildlife Commission listed coho salmon north of San Francisco Bay under the California Endangered Species Act (CESA). CDFW created both a multi-stakeholder coho recovery team to address rangewide recovery issues, and a sub-working group to develop coho salmon recovery strategies associated specifically with agricultural management within the Scott and Shasta rivers to return coho salmon to a level of viability so that they can be delisted.

In 2002, NMFS began ESA recovery planning for the SONCC and Oregon Coast coho salmon ESU through a scientific technical team created and chaired by the Northwest and Southwest Regional Fishery Science Centers, referred to as the Oregon and Northern California Coast coho salmon technical recovery team. As a part of the larger technical recovery team, a SONCC working group is focusing on coho salmon populations within the SONCC coho salmon ESU, which includes all populations within the Klamath River basin. NMFS prepared a draft recovery plan for the SONCC coho salmon ESU (77 FR 476; January 5, 2012), and requested public comments on the draft recovery plan until May 4, 2012 (77 FR 7134; February 10, 2012).

NMFS administers several grant programs to further restoration efforts in the Klamath River Basin. Since 2000, NMFS has issued grants to the States of California and Oregon, and Klamath River Basin tribes (Yurok, Karuk, Hoopa Valley and Klamath) through the Pacific Coast Salmon Restoration Fund (PCSRF) for the purposes of restoring coastal salmonid habitat. California integrates the PCSRF funds with their salmon restoration funds and issues grants for habitat restoration, watershed planning, salmon enhancement, research and monitoring, and outreach and education.

Restoration activities are expected to benefit coho salmon and their critical habitat. These effects are expected to continue throughout the duration of the action, possibly increasing during that time period. Passage improvements have reintroduced access to critical habitat. Restoration activities are expected to improve upon one or more of the VSP parameters for the interior Klamath populations.

11.3.8.7 Mining

Mining activities within the Klamath River Basin began prior to 1900. Many of the communities in the Klamath River Basin originated with the gold mining boom of the 1800s. Water was diverted and pumped for use in sluicing and hydraulic mining operations. This resulted in dramatic increases in turbidity levels altering stream morphology. The negative impacts of stream sedimentation on fish abundance were observed as early as the 1930s. Mining operations adversely affected spawning gravels, which resulted in increased poaching activity, decreased survival of fish eggs and juveniles, decreased benthic invertebrate abundance, adverse effects to water quality, and impacts to stream banks and channels. Since the 1970s, large-scale commercial mining operations have been eliminated due to stricter environmental regulations.

Since August 6, 2009, all California instream suction dredge mining was suspended following the Governor’s signature on a new state law. The moratorium on instream suction dredge mining took effect immediately as an urgency measure, prohibiting the use of vacuum or other suction dredging equipment for instream mining in reliance on any permit previously issued by CDFW (CDFG 2010). On July 26, 2011, Assembly Bill 120 was signed into State law, which extended the moratorium until June 30, 2016.

11.3.8.8 Road maintenance and culvert replacement

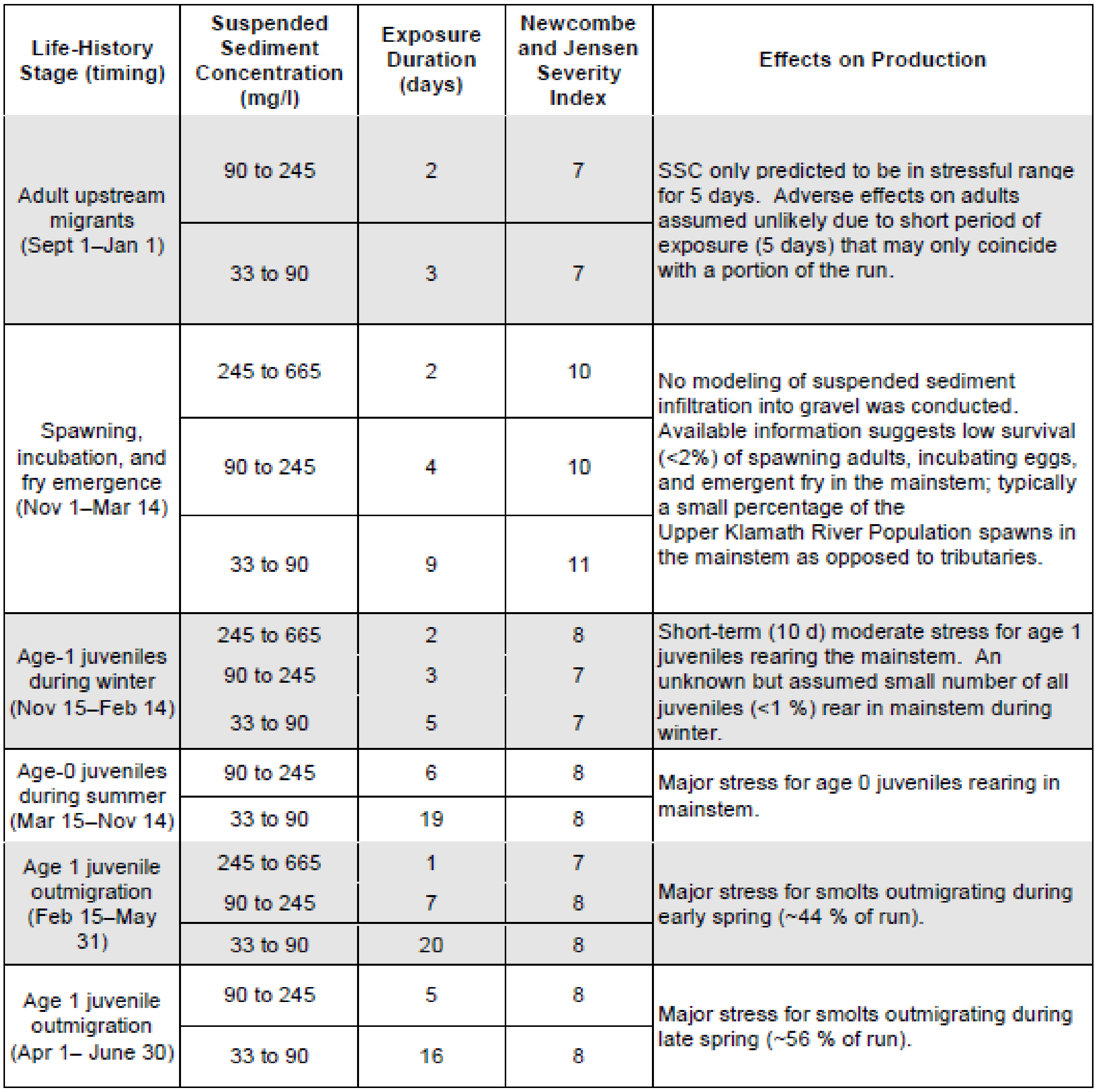
In 2000, NMFS issued a final rule with protective regulations for threatened salmonids pursuant to ESA section 4(d) (65 FR 42422; July 10, 2000). Limit number 10 of the prohibitions in these regulations relates to road maintenance activities (50 CFR 222.203(b)(10)). Specifically, this limit provides that the prohibitions of taking threatened salmonids in these regulations do not apply to road maintenance activities if the activity results from routine road maintenance conducted by the employees or agents of a state, county, city, or port under a program that complies with a routine road maintenance program substantially similar to the “Transportation Maintenance Management System Water Quality and Habitat Guide [Oregon Department of Transportation (ODOT) 1999].” To qualify their road programs under Limit 10, Humboldt, Del Norte, Trinity, Siskiyou and Mendocino Counties (Five Counties) collaboratively developed the “Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds” (Five Counties Salmon Conservation Program 2002) which is based largely on ODOT (1999). In November 1999, the California Resources Agency convened a group of interested state, local and federal agencies, fisheries conservation groups, researchers, restoration contractors, and others to discuss ways to restore and recover anadromous salmonid populations by improving fish passage at fabricated barriers. Now recognized as the Fish Passage Forum, this diverse group meets on a quarterly basis to promote the protection and restoration of listed anadromous salmonid species in California, primarily by encouraging collaboration among public and private sectors for fish passage improvement projects and programs. Road maintenance and culvert replacement will likely benefit coho salmon in the action area.

These effects are expected to continue throughout the duration of the action, and beyond. Road maintenance and culvert activities may have a neutral or, in many cases, a positive effect upon all of the VSP parameters for the interior Klamath populations. For instance, reestablishing historical habitat associated with opening new spawning areas can potentially increase the spatial structure of the SONCC coho salmon ESU.

11.3.8.9 Suspended Sediment Concentrations

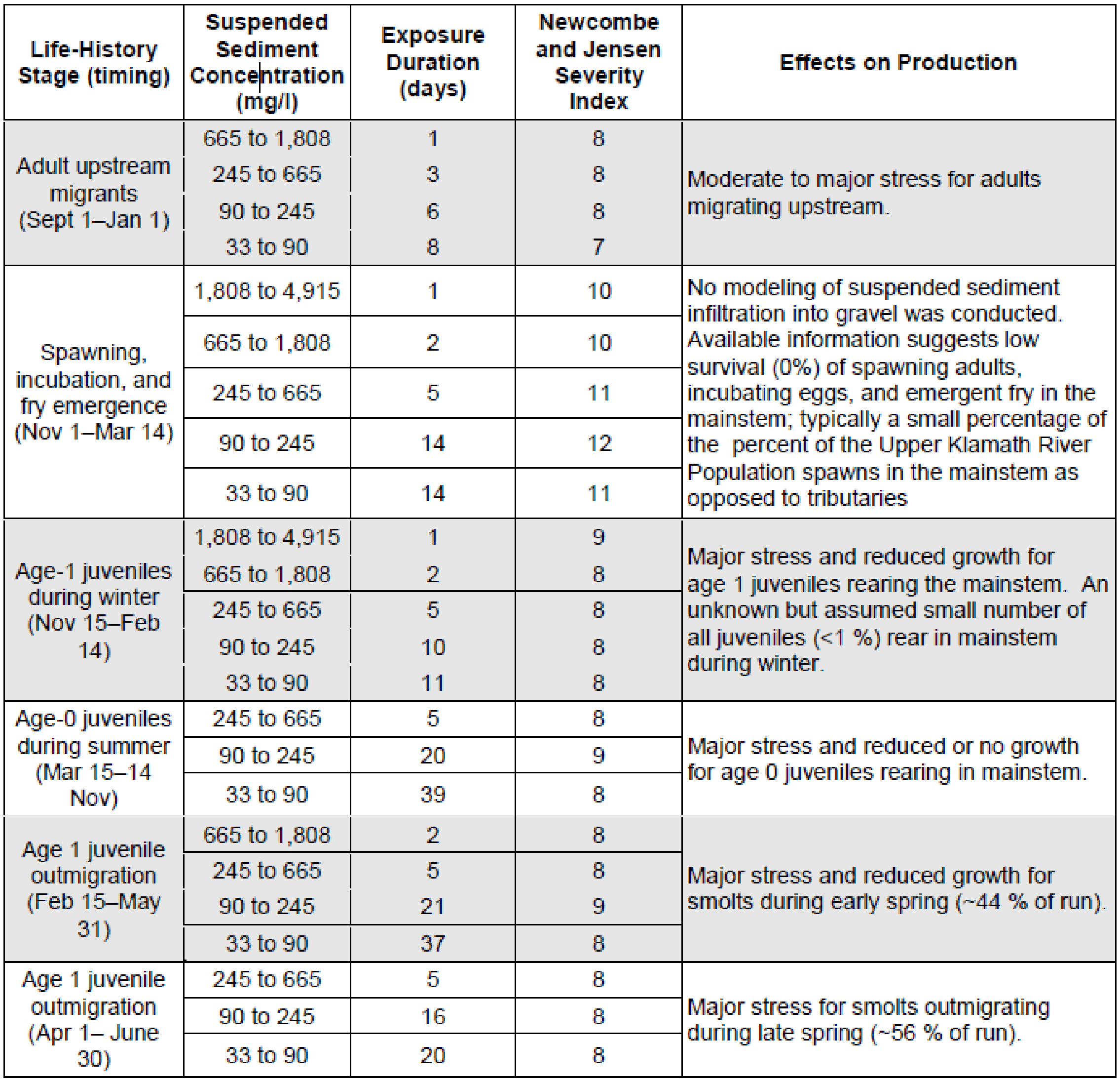
Currently, suspended sediment concentrations in the mainstem Klamath River are sufficiently high and long in duration under normal and extreme conditions (Tables 11.4 and 11.5) that major physiological stress and reduced growth of coho salmon are expected in most years for certain life stages. In addition, tributary rearing habitat currently accessed by Klamath River coho salmon is compromised to some degree, most commonly by high instream sediment concentrations or impaired riparian communities (see NMFS 2007 for review). High instream sediment concentrations can fill pools and simplify instream habitat, whereas impaired riparian habitat can exacerbate streamside erosion rates and hinder wood input to the stream environment (Spence et al. 1996). Both of these processes are common within the Middle and Lower Klamath Populations, where wide-scale timber harvests have occurred in many tributary basins.

Table 11.4. Modeled suspended sediment concentrations, exposure durations, and likely effects to coho salmon under existing normal conditions (50 percent exceedance probability), for Klamath River at Seiad Valley (RM 129; USDOI and CDFW 2013).



Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1–Jan 1)	90 to 245	2	7	SSC only predicted to be in stressful range for 5 days. Adverse effects on adults assumed unlikely due to short period of exposure (5 days) that may only coincide with a portion of the run.
	33 to 90	3	7	
Spawning, incubation, and fry emergence (Nov 1–Mar 14)	245 to 665	2	10	No modeling of suspended sediment infiltration into gravel was conducted. Available information suggests low survival (<2%) of spawning adults, incubating eggs, and emergent fry in the mainstem; typically a small percentage of the Upper Klamath River Population spawns in the mainstem as opposed to tributaries.
	90 to 245	4	10	
	33 to 90	9	11	
Age-1 juveniles during winter (Nov 15–Feb 14)	245 to 665	2	8	Short-term (10 d) moderate stress for age 1 juveniles rearing the mainstem. An unknown but assumed small number of all juveniles (<1 %) rear in mainstem during winter.
	90 to 245	3	7	
	33 to 90	5	7	
Age-0 juveniles during summer (Mar 15–Nov 14)	90 to 245	6	8	Major stress for age 0 juveniles rearing in mainstem.
	33 to 90	19	8	
Age 1 juvenile outmigration (Feb 15–May 31)	245 to 665	1	7	Major stress for smolts outmigrating during early spring (~44 % of run).
	90 to 245	7	8	
	33 to 90	20	8	
Age 1 juvenile outmigration (Apr 1– June 30)	90 to 245	5	8	Major stress for smolts outmigrating during late spring (~56 % of run).
	33 to 90	16	8	

Table 11.5. Modeled suspended sediment concentrations, exposure durations, and likely effects to coho salmon under existing extreme conditions (10 percent exceedance probability), for Klamath River at Seiad Valley (RM 129; USDOI and CDFW 2013).



Life-History Stage (timing)	Suspended Sediment Concentration (mg/l)	Exposure Duration (days)	Newcombe and Jensen Severity Index	Effects on Production
Adult upstream migrants (Sept 1–Jan 1)	665 to 1,808	1	8	Moderate to major stress for adults migrating upstream.
	245 to 665	3	8	
	90 to 245	6	8	
	33 to 90	8	7	
Spawning, incubation, and fry emergence (Nov 1–Mar 14)	1,808 to 4,915	1	10	No modeling of suspended sediment infiltration into gravel was conducted. Available information suggests low survival (0%) of spawning adults, incubating eggs, and emergent fry in the mainstem; typically a small percentage of the percent of the Upper Klamath River Population spawns in the mainstem as opposed to tributaries
	665 to 1,808	2	10	
	245 to 665	5	11	
	90 to 245	14	12	
	33 to 90	14	11	
Age-1 juveniles during winter (Nov 15–Feb 14)	1,808 to 4,915	1	9	Major stress and reduced growth for age 1 juveniles rearing the mainstem. An unknown but assumed small number of all juveniles (<1 %) rear in mainstem during winter.
	665 to 1,808	2	8	
	245 to 665	5	8	
	90 to 245	10	8	
	33 to 90	11	8	
Age-0 juveniles during summer (Mar 15–14 Nov)	245 to 665	5	8	Major stress and reduced or no growth for age 0 juveniles rearing in mainstem.
	90 to 245	20	9	
	33 to 90	39	8	
Age 1 juvenile outmigration (Feb 15–May 31)	665 to 1,808	2	8	Major stress and reduced growth for smolts during early spring (~44 % of run).
	245 to 665	5	8	
	90 to 245	21	9	
	33 to 90	37	8	
Age 1 juvenile outmigration (Apr 1– June 30)	245 to 665	5	8	Major stress for smolts outmigrating during late spring (~56 % of run).
	90 to 245	16	8	
	33 to 90	20	8	

11.3.8.10 Fish Disease

The following baseline information on aquatic diseases is mostly from *Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River* (Hamilton et al. 2011) and the Klamath Facilities Removal environmental impact statement/environmental impact report (USDOI and CDFW 2013).

Existing data and observations in the Klamath River indicate that the most common pathogens of concern can be grouped into four categories: (1) viral pathogens such as infectious haematopoietic necrosis; (2) the bacterial pathogens *R. salmoniranrum* (bacterial kidney disease), *Flavobacterium columnare* (columnaris), and *Aeromonas hydrophila*; (3) external protozoan parasites *Ichthyophthirius* (Ich), *Ichthyobodo*, and *Trichodina*; and (4) the myxozoan parasites *Ceratomyxa shasta* (causes ceratomyxosis) and *Parvicapsula minibicornis*. There is a lack of information concerning the presence of infectious haematopoietic necrosis and bacterial kidney disease either above or below IGD (Administrative Law Judge 2006). *Columnaris* is common worldwide and present at all times in the aquatic environment. *Columnaris* disease in cold water fishes is generally seen at water temperatures above 15 ^{o}C. In natural infections, the disease is often chronic to subacute, affecting skin and gills (CDFG 2004a). Ich infestation of gill tissue results in hyperplasia, a condition that reduces the ability of the fish to obtain oxygen. Death is by asphyxiation. Ich can be found on any fish at any temperature, but typically only causes disease and mortality at water temperatures above 14^{o}C and in crowded conditions (CDFG 2004a). Other common pathogens are likely present in the Klamath River, but are reported rarely.

Ich and columnaris have occasionally had a substantial impact on adult salmon downstream of IGD, particularly when habitat conditions include exceptionally low flows, high water temperatures, and high densities of fish (such as adult salmon migrating upstream in the fall and holding at high densities in pools). In 2002, these habitat factors were present, and a disease outbreak occurred, with more than 33,000 adult salmon and steelhead losses, including an estimated 334 coho salmon (Guillen 2003). Most of the fish affected by the 2002 fish die-off were fall-run Chinook salmon in the lower 36 miles of the Klamath River (CDFG 2004a). Although losses of adult salmonids can be substantial when events such as the 2002 fish die-off occur, the combination of factors that leads to adult infection by Ich and columnaris disease may not be as frequent as the annual exposure of juvenile salmonids to *C. shasta* and *P. minibicornis*, as many juveniles must migrate each spring downstream past established populations of the invertebrate polychaete worm host.

The life cycles of both *C. shasta* and *P. minibicornis* involve an invertebrate and a fish host, where these parasites complete different parts of their life cycle. In the Klamath River, *P. minibicornis* and *C. shasta* share the same invertebrate host: an annelid polychaete worm, *Manayunkia speciosa* (Bartholomew et al. 2006). Once the polychaetes are infected, they release *C. shasta* actinospores into the water column. Temperature and actinospore longevity are inversely related. In one study, actinospores remained intact the longest at 4°C, but were short-lived at 20°C. Actinospores are generally released when temperatures are above 10°C, and remain viable (able to infect salmon) from 3 to 7 days at temperatures ranging from 11 to 18ºC (Foott et al. 2006). When temperatures are outside of 11 to 18ºC, actinospores are viable for a shorter time. As actinospore viability increases, actinospore distribution may increase, raising the infectious dose for salmon over a larger area of the river (Bjork and Bartholomew 2010). Actinospore abundance, a primary determinant of infectious dose, is controlled by the number of polychaetes and the prevalence and severity of infection within their population.

Salmon become infected when the actinospores enter the gills, and eventually reaching the intestines. At that point, the parasite replicates and matures to the myxospore stage. Myxospores are shed by the dying and dead salmon, and the cycle continues with infection of polychaete worms by the myxospores (Bartholomew and Foott 2010). Transmission of the *C. shasta* and *P. minibicornis* parasites is limited to areas where the invertebrate host is present.

Susceptibility to *C. shasta* is also influenced by the genetic type of *C. shasta* that a fish encounters. Atkinson and Bartholomew (2010a, 2010b) conducted analyses of the genotypes of

C. shasta and the association of these genotypes with different salmonid species, including Chinook and coho salmon, steelhead, rainbow trout, and redband trout. The *C. shasta* genotypes affecting coho salmon are characterized as Type II and Type III:

- The Type II genotype occurs in and above UKL and below IGD, and at low levels between the dams, and affects coho salmon and nonnative rainbow trout. However, it appears that the biotype of this parasite in the upper basin does not affect coho salmon.
- Type III appears widespread based on fish infections. Type III appears to infect all salmonid species (Atkinson and Bartholomew 2010a). Prevalence of this genotype is low and it infects fish but does not appear to cause mortality.

The polychaete host for *C. shasta* is present in a variety of habitat types, including runs, pools, riffles, edge-water, as well as sand, gravel, boulders, bedrock, aquatic vegetation, and is frequently present with *Cladophora* (a type of algae) (Bartholomew and Foott 2010). The altered river channel below IGD has resulted in atypically stable river bed, which provides favorable habitat for the polychaete worm. Slow-flowing habitats may have higher densities of polychaetes, and areas that are more resistant to disturbance, such as eddies and pools with sand and *Cladophora*, may support increased densities of polychaete populations (Bartholomew and Foott 2010), especially if flow disturbance events are reduced or attenuated. High polychaete densities increases parasite loads, which leads to higher rates of infection and mortality for coho salmon.

Stocking and Bartholomew (2007) noted that the ability of some polychaete populations to persist through disturbances (e.g., large flow events) indicates that the lotic populations are influenced by the stability of the microhabitat they occupy. In the lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations mostly concentrated between the Interstate 5 bridge and the Trinity River confluence, and especially above the Scott River (Stocking and Bartholomew 2007). The reach of the Klamath River from the Shasta River (RM 176.7) to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores, especially from May through August (Beeman et al. 2008).

This reach of the Klamath River contains dense populations of polychaetes in low-velocity habitats with *Cladophora* (a type of green algae), sand-silt, and fine benthic organic material in the substrate (Stocking and Bartholomew 2007). High parasite prevalence in the mainstem Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream of IGD and the proximity to dense populations of polychaetes (Bartholomew et al. 2007). The highest rates of infection occur in the Klamath River downstream of IGD (Stocking and Bartholomew 2007, Bartholomew and Foott 2010). Infection prevalence in polychaete host populations was an order of magnitude greater in the reach between the Tree of Heaven and Interstate 5 than at any other site throughout the river (Stocking and Bartholomew 2007).

Despite potential resistance to the disease in native populations, fish (particularly juvenile fish, and more so at higher water temperatures) exposed to high levels of the parasite may be more susceptible to disease. Coho salmon migrating downstream have been found to have infection rates as high as 50 percent (Bartholomew and Foott 2010). The number of juvenile salmonids that become infected is estimated to be 10 to 70 percent annually based on surveys of fish captured in the river (True et al. 2010). High infection rates are apparently resulting in high mortality of outmigrating smolts. Studies of outmigrating coho salmon smolts by Beeman et al. (2008) estimated that disease-related mortality rates were between 35 and 70 percent in the Klamath River near IGD. Their studies suggest that higher spring discharge increased smolt survival (Beeman et al. 2008). In 2008, mortality rates were as high as 85 percent in May (7-day exposure for age 1+ coho smolts) and 96 percent (age 0+ coho smolts).

Foott et al. (1999) found that when water temperatures are under 17 °C, Klamath River salmonids appear to be more resistant to ceratomyxosis. The risk of mortality from ceratomyxosis was lowest as water temperatures increased from 13 to 15 °C, and was greatest as temperatures increased from 18 to 21 °C (Ray et al. 2012). In 2010, water temperatures did not exceed 16 °C until June, which was two to three weeks later than previous years. The delay in warmer water temperatures may have hindered the development of the polychaete host, the actinospore stage of *C. shasta* within the polychaete, or both (Ray et al. 2012). While the water years between 2007 and 2010 were very similar, coho salmon mortality in 2010 from ceratomyxosis was low compared with previous years (Ray et al. 2012).

Disease effects are likely to negatively impact all of the VSP parameters of the Interior-Klamath populations because both adults and juveniles can be affected. In terms of critical habitat, disease impacts adult and juvenile migration corridors, and juvenile spring and summer rearing areas.

11.3.8.11 Climate Change

Climate change is likely to have both negative and positive effects on the SONCC coho salmon populations in the action area. Coho salmon populations in the Klamath basin will have their freshwater habitat detrimentally affected by alterations in river flows and water temperature as a result of climate change. However, increased rainfall may increase the duration that intermittent streams serve as refuges from high mainstem flows.

The hydrologic characteristics of the Klamath River mainstem and its major tributaries are dominated by seasonal melt of snowpack (NRC 2004). Van Kirk and Naman (2008) found statistically significant declines in April 1 snow water equivalent since the 1950s at several snow measurement stations throughout the Klamath basin, particularly those at lower elevations (<6000 ft.). Mayer (2008) found declines in winter precipitation in the upper-Klamath basin. The overall warming trend that has been ubiquitous throughout the western United States (Groisman et al. 2004), particularly in winter temperatures over the last 50 years (Feng and Hu 2007, Barnett et al. 2008), has caused a decrease in the proportion of precipitation falling as snow (Feng and Hu 2007).

Basins below approximately 1800-2500 m in elevation appear to be the most impacted by reductions in snowpack (Knowles and Cayan 2004, Regonda et al. 2005, Mote 2006). Over the last 50 years, some of the largest declines in snowpack over the Western U.S. have been in the Cascade Mountains and Northern California (Mote et al. 2005, Mote 2006). Regonda et al. (2005) analyzed western states data from 1950 through 1999, including data from the Cascade Mountains of southern Oregon, and found a decline in snow water equivalent of greater than 6 inches (15.24 cm) during March, April, and May in the southern Oregon Cascades for the 50-year period evaluated. A decline of 6 inches (15.24 cm) equals an approximate 20 percent reduction in snow water equivalent. Declines in snowpack are expected to continue in the Klamath basin.

Recent winter temperatures are as warm as or warmer than at any time during the last 80 to 100 years (Mayer 2008). Air temperatures over the region have increased by about 1.8º to 3.6º F (1° to 2º C) over the past 50 years and water temperatures in the Klamath River and some tributaries have also been increasing (Bartholow 2005; Flint and Flint 2012). Reclamation (2011a) reports that the mean annual temperature in Jackson and Klamath Counties, Oregon, and Siskiyou County, California, increased by slightly less than 1 °C between 1970 and 2010. During the same period, total precipitation for the same counties decreased by approximately 2 inches (5.08 cm; Reclamation 2011a).

Analysis of climatologic and hydrologic information for the upper Klamath Basin indicates Upper Klamath Lake inflows, particularly base-flows, have declined over the last several decades (Mayer and Naman 2011). Recent analyses completed for this BiOp confirm the trend in declining inflow to Upper Klamath Lake and also demonstrate declining flows in the Williamson and Sprague rivers (major tributaries to Upper Klamath Lake) from 1981 through 2012. Net inflow to Upper Klamath Lake and flow in the Williamson and Sprague rivers are strongly dependent on climate, particularly precipitation (Mayer and Naman 2011). Part of the decline in flow is explained by changing patterns in precipitation; however, other factors are very likely involved as well, including increasing temperature, decreasing snow water equivalent, increasing evapotranspiration, or possible increasing surface water diversions or groundwater pumping upstream of the lake (Mayer 2008; Mayer and Naman 2011).

Projections of the effects of climate change in the Klamath Basin suggest temperature will increase in comparison to 1961 through 2000 time period (Barr et al. 2010; Reclamation 2011a). Projections are based on ensemble forecasts from several global climate models and carbon emissions scenarios. Although none of the projections include data for the specific period of the proposed action, anticipated temperature increases during the 2020s compared to the 1990s range from 0.9 to 1.4° F (0.5 to 0.8° C) (Reclamation 2011a).

Effects of climate change on precipitation are more difficult to project and models used for the Klamath Basin suggest decreases and increases. During the 2020s, Reclamation (2011a) projects an annual increase in precipitation of approximately 3 percent compared to the 1990s. Reclamation (2011a) also suggests that an increase in evapotranspiration will likely offset the increase in precipitation.

Reclamation (2011a) projects that snow water equivalent during the 2020s will decrease throughout most of the Klamath Basin, often dramatically, from values in the 1990s. Projections suggest that snow water equivalent will decrease 20 to 50 percent in the high plateau areas of the upper basin, including the Williamson River drainage. Snow water equivalent is expected to decrease by 50 to 100 percent in the Sprague River basin and in the vicinity of Klamath Falls. In the lower Klamath Basin, Reclamation projects decreases in snow water equivalent between 20 and 100 percent. The exception to the declines is the southern Oregon Cascade Mountains, where snow water equivalent is projected to be stable or increase up to 10 percent (Reclamation 2011a).

Reclamation (2011a) also projects annual increases in runoff during the 2020s compared to the 1990s, based on the global climate models. The annual volume of flow in the Williamson River is expected to increase by approximately 8 percent, with increases of approximately 22 percent during December through March and decreases of approximately 3 percent during April through July (Reclamation 2011a). The Klamath River below IGD is expected to experience an approximate 5 percent increase in annual flow volume, with increases of approximately 30 percent during December through March and decreases of approximately 7 percent during April through July (Reclamation 2011a). The apparent contradiction between decreasing snow water equivalent and increasing runoff is resolved by projections suggesting a greater proportion of precipitation will fall as rain instead of snow, and the increase in overall precipitation will be greater in the winter than in the summer. Summer flows are still likely to be lower in both projections.

Bartholow (2005) found that the Klamath River is increasing in water temperature by 0.5°C per decade, which may be related to warming trends in the region (Bartholow 2005) and/or alterations of the hydrologic regime resulting from the dams, logging, and water use in Klamath River tributary basins. Particularly, changes in the timing of peak spring discharge, and decreases in water quantity in the spring and summer may affect salmonids of the Klamath River. Most life history traits (e.g., adult run timing, juvenile migration timing) in Pacific salmon have a genetic basis (Quinn et al. 2000, Quinn 2005) that has evolved in response to watershed characteristics (e.g., hydrograph) as reflected in the timing of their key life-history features (Taylor 1991, NRC 2004). In their natural state, anadromous salmonids become adapted to the specific conditions of their natal river like water temperature and hydrologic regime (Taylor 1991, NRC 2004). Therefore, the ability of individuals and populations to adapt to the extent and speed of changes in water temperatures and hydrologic regimes of the Klamath River basin will determine whether or not coho salmon of the Klamath River are capable of adapting to changing river conditions.

Reclamation (2011a) and Woodson et al. (2011) suggest that projected climate change have the following potential effects for the basin:

- Warmer conditions might result in increased fishery stress, reduced salmon habitat, increased water demands for instream ecosystems and increased likelihood of invasive species infestations (Reclamation 2011a).
- Water demands for endangered species and other fish and wildlife could increase due to increased air and water temperatures and runoff timing changes (Reclamation 2011a).
- Shorter wet seasons projected by most models will likely alter fish migration and timing and possibly decrease the availability of side channel and floodplain habitats (Woodson et al 2011).
- Groundwater fed springs will decrease and may not flow year around (Woodson et al 2011)
- Disease incidence on fishes will increase (Woodson et al 2011)
- Dissolved oxygen levels will fluctuate more widely, and algae blooms will be earlier, longer, and more intense (Woodson et al 2011).

In addition to having multiple hydrologic effects, climate change may affect biological resources in the Klamath Basin. Climate change could exacerbate existing poor habitat conditions for fish by further degrading water quality. Climate change may at best complicate recovery of coho salmon, or at worst hinder their persistence (Beechie et al. 2006, Van Kirk and Naman 2008). By negatively affecting freshwater habitat for Pacific salmonids (Mote et al. 2003, Battin et al. 2007), climate change is expected to negatively impact one or more of the VSP criteria for the interior Klamath populations. Climate change can reduce coho salmon spatial structure by reducing the amount of available freshwater habitat. Diversity could also be impacted if one specific life history strategy is disproportionately affected by climate change. Population abundance may also be reduced if fewer juveniles survive to adulthood. Climate change affects critical habitat by decreasing water quantity and quality, and reducing the amount of space available for summer juvenile rearing.

In terms of future climate change effects on coho salmon in the Klamath River basin, NMFS does not believe climate changes within the period of the proposed action would have noticeable additional effects on coho salmon or its critical habitats beyond what has been occurring.

11.4 Effects to SONCC Coho Salmon ESU Critical Habitat

The proposed action affects SONCC coho salmon ESU critical habitat through the Project Operations and the annual restoration fund of approximately $500,000. Note that the use of the term “proposed action” in the *Project Operations* section represents the Klamath Project operations component of the proposed action, while the use of the term “proposed action” in the *Restoration Activities* section represents the habitat restoration component of the proposed action.

11.4.1 Project Operations

The hydrologic effects analysis is based on the results from the formulaic approach described in the proposed action and on one element of the proposed environmental water account management (adaptive management) where details are sufficient for analysis. Besides the proposed real-time management for minimizing disease risks, NMFS does not have sufficient information on other elements of this adaptive management approach to analyze how or when these deviations would occur. Details of the adaptive management approach are likely to be contained in a yet-to-be developed draft flow scheduling guideline (Reclamation 2012).

In addition, while NMFS recognizes that deviations from the formulaic approach via the proposed adaptive management may be used to minimize adverse effects to SONCC coho salmon and its critical habitat, NMFS does not have reasonable certainty that Reclamation will deviate from the formulaic approach to minimize adverse effects to coho salmon or its critical habitat. The adaptive management process currently encompasses convening several stakeholder groups (i.e., the Flow Account Scheduling Technical Advisory team and the Klamath Flow Management Group) before ultimately getting Reclamation’s approval for deviations. Considerations of these future groups will include balancing the costs and benefits of deviations from the formulaic approach on both listed suckers and coho salmon. Except for the process of minimizing disease risks, the details of this future process are yet to be developed. Therefore, except as it relates to minimizing disease risks, the effects of the adaptive management resulting in potential deviations from the formulaic approach as described in Reclamation's Final BA (i.e., Section 4.3.4 Implementing Environmental Water Account Management; Reclamation 2012) are not evaluated in our effects analysis.

Therefore, under the formulaic approach of the proposed action, the annual median Project delivery from all sources by water year is 428,200 acre-ft with a minimum of 178,000 acre-ft and a maximum of 477,000 acre-ft (Reclamation 2012). Approximately 80 percent of the Project water delivery is not returned to the mainstem Klamath River (Cameron 2013), while approximately 20 percent is returned as agricultural tailwater. The Project's effects to coho salmon critical habitat result from the Project's influence of flows at IGD.

11.4.1.1 Hydrologic Effects

The following discussion describes the differences between the Klamath River natural flow regime under relatively unimpaired conditions defined by the 1905-1913 discharge dataset at Keno, Oregon and the resulting flow regime from implementation of the proposed action. The natural flow regime of a river is characterized by the pattern of flow quantity, timing, duration and variability across time scales, all without the influence of human activities (Poff et al. 1997). Operation of the Project affects all components of the natural flow regime. In this BiOp, NMFS recognizes the environmental and human caused factors that have influenced the hydrological shift from the natural flow regime, including the effects of the Klamath Project. Here NMFS assesses the Project's effects on flow volume, magnitude, timing, duration, flow variability, and channel maintenance flows with consideration of the other factors contributing to the current Klamath River hydrology. For these analyses, NMFS calculated the 7-day moving average of the proposed action modeled daily flows at IGD because NMFS believes the 7-day moving average better represents operationally implementable flows under the proposed action. However, the proposed action modeled daily discharge at IGD was not converted to a 7-day moving average for the analysis on channel maintenance flows based on recent clarifications that Reclamation made to ensure implementation of the proposed action modeled daily peak flows (Reclamation 2013b).

The proposed action hydrograph at IGD is also compared to the observed hydrograph at IGD for the 1981-2011 POR because an unimpaired, historic daily discharge dataset at IGD is not available for comparison. These comparisons to the 1981-2011 POR allow NMFS to evaluate whether the proposed action will result in a trend of the Klamath River hydrograph towards, or away from, the natural flow regime. When the proposed action hydrograph at IGD exhibits better hydrologic conditions (e.g., higher peak flow magnitude, higher flow volume, or enhanced variability) in the mainstem Klamath River relative to the observed POR hydrograph, the proposed action trends towards the natural flow regime. Conversely, when the proposed action hydrograph at IGD exhibits worse hydrologic conditions (e.g., lower peak flow magnitude, lower flow volume, or diminished variability) in the mainstem Klamath River relative to the observed POR hydrograph, the proposed action trends away from the natural flow regime. The characteristics of the Klamath River natural flow regime are important to maintain because those are the hydrologic conditions that coho salmon evolved under. As the basis for its ultimate conclusions in this BiOp regarding hydrologic effects of the action, NMFS compares the effects of the proposed action to the Klamath River natural flow regime. NMFS acknowledges that the historic discharge dataset at Keno is limited and likely does not represent the full range of hydrologic conditions that occurred in the 1981-2011 POR. The 1981-2011 POR contains both extremely wet (e.g. 1982, 1983, and 1984) and extremely dry (e.g., 1991, 1992, and 1994) water years which likely encompasses the full range of hydrologic conditions NMFS expects to occur in the next 10 years. The long term rainfall record for Klamath Falls, Oregon suggests that the 1905-1913 period had slightly above average precipitation, (i.e., 104 percent of average for the period 1905 through 1994) with slightly above average runoff for much of the upper Klamath Basin (Hecht and Kamaan 1996). However, the 1905-1913 annual hydrographs were likely not representative of the full range of hydrologic conditions because very wet and very dry annual hydrographs appear to be absent from this period (Trush 2007).

11.4.1.1.1 Characteristics of the Natural Flow Regime

Reclamation proposes to manage flows in the Klamath River in a manner that approximates the natural hydrograph, represented by real-time climatological and hydrological conditions. For this discussion, the natural hydrograph is defined by the 1905-1913 discharge dataset at Keno, Oregon (Figure 11.4). The 1905-1913 Keno discharge dataset represents historic and relatively unimpaired river flow before implementation of the Klamath Project and other human caused factors influencing the current hydrological baseline (e.g., PacifiCorp's dams, off-Project water users). Reclamation's actions of storing and delivering Project water, and meeting ESA needs of endangered suckers, combined with other factors outside of Reclamation's discretion, limit the volume of water available for Reclamation to approximate the natural hydrograph (Figure 11.4). Based upon our evaluation, greater than one third of the median annual UKL net inflow (1105 TAF) is diverted to the Project annually.

Under the proposed action, the average daily hydrograph at Keno, Oregon approximates the shape of the natural hydrograph but will have a lower magnitude and duration of peak discharge with a shift of more than one month, from the end of April to the middle of March, relative to the historic average daily hydrograph at Keno for the 1905-1913 period (Figure 11.4). Additionally, spring and summer discharge is substantially reduced. Historically, Klamath River discharge did not reach base (minimum) flow until September. After implementation of the Project, minimum flows occur in the beginning of July, a shift earlier in base flow minimum of roughly two months. The proposed action hydrograph at IGD has a similar shape to the proposed action hydrograph at Keno and illustrates the characteristics of the flow regime (shape, timing, and variability) evidenced at Keno, but IGD has a higher peak magnitude and flow volume due to accretions between Keno and Iron Gate dams (Figures 11.4 and 11.5).

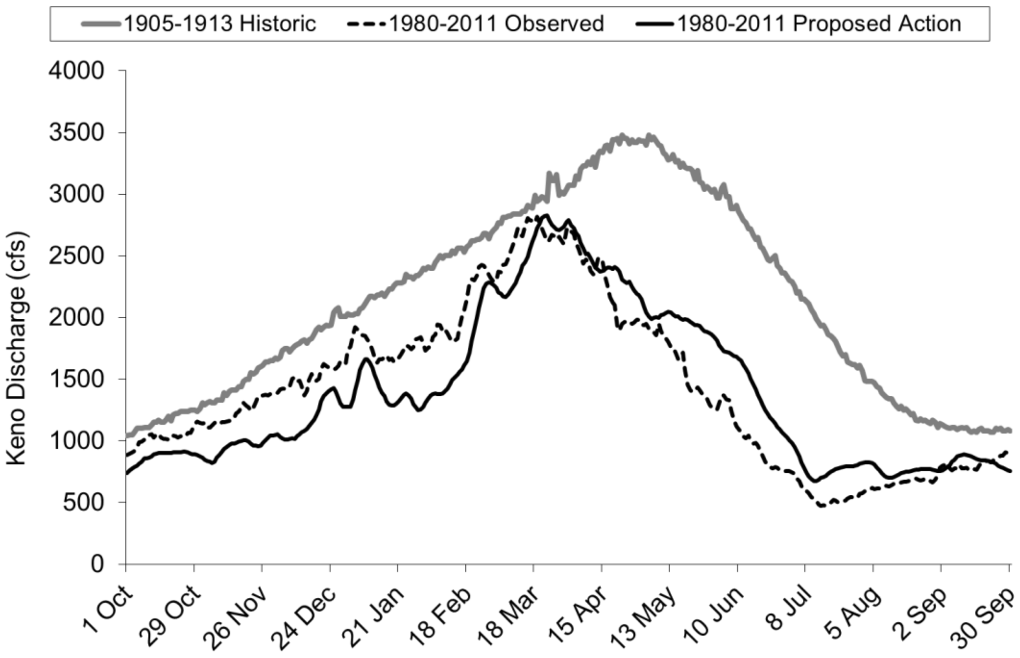


Figure 11.4. Proposed action, historic and observed average daily Klamath River discharge at Keno, Oregon. The 1905-1913 dataset represents historic and relatively unimpaired river flow before implementation of the Klamath Project. Proposed action average daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

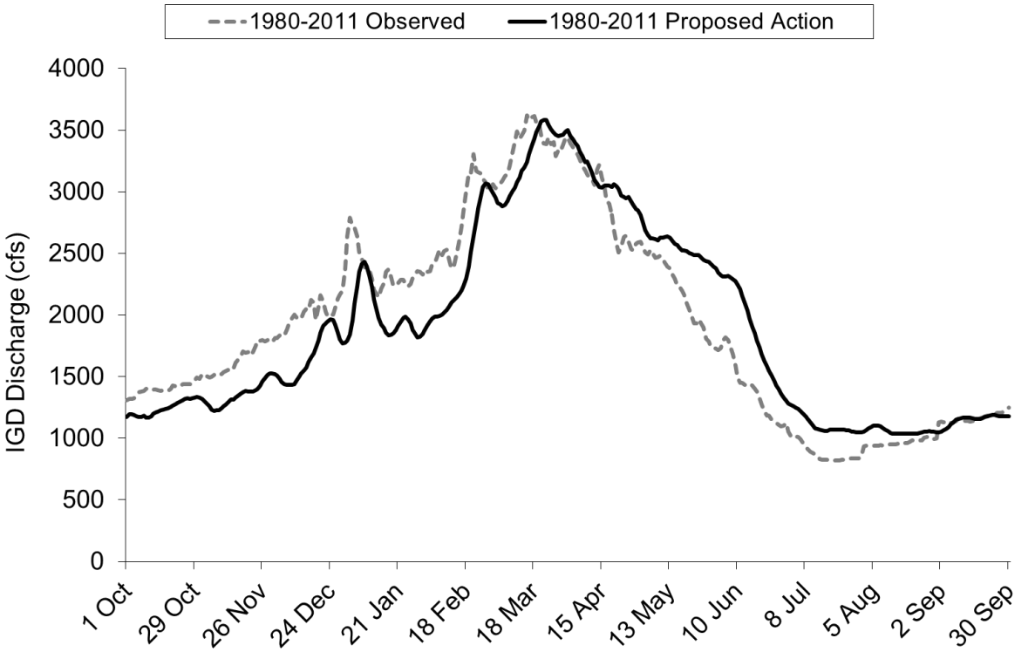


Figure 11.5. Proposed action and observed average daily Klamath River discharge at IGD. proposed action average daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

The proposed action results in a hydrograph that approximates the shape of the natural flow regime under a broad range of hydrologic conditions (Figures 11.4 and 11.6). However, the proposed action hydrograph at IGD will have lower base flows with relatively small incremental increases through mid-February compared to the natural hydrograph (Figures 11.4 and 11.5). This departure from the natural flow regime is partly a result of the proposed action's prioritization of refilling UKL during this period. Without the Project operating, end of summer UKL elevations would often be higher, generally resulting in higher base flows in the Klamath River that would incrementally increase in the fall and winter as inflow and precipitation increase because a smaller percentage of inflow would be required for storage in UKL.

Additionally, the Project's inter-annual water year effects from diverting a median of 428,200 acre-ft annually lowers the elevation of UKL throughout the spring, summer and fall, thereby increasing the amount of storage required to re-fill UKL the following year. Therefore, the effects of the proposed action on flows in the Klamath River are often a result of water use by the Project not only in the current year, but also in previous years. The Klamath River is especially susceptible to the risk of sequential dry hydrologic conditions due to limited storage in UKL (PacifiCorp 2012b) and a drier climate in the upper watershed as suggested by the more recent five to ten years of data (PacifiCorp 2012b). Because of the annual water diversion for Project irrigation and the inter-annual effect of increasing the amount of storage needed to refill UKL, the proposed action creates drier conditions in the Klamath River and increases the likelihood of consecutive drier years in the Klamath River (e.g., converts average water year in the upper Klamath Basin into below average water year in the mainstem Klamath River). In the 10 year period of the proposed action, consecutive years of relatively dry climatological conditions will likely result in extended periods of relatively low flows with minimal variability at IGD. The proposed action hydrograph at Keno indicates an earlier and lower peak discharge in the spring, an earlier return to base flows, and flows that are generally lower in magnitude relative to the natural hydrograph (Figure 11.4). These changes to the hydrograph are primarily a result of the proposed action storing and delivering Project water, and also meeting ESA needs of endangered suckers, combined with other factors outside of Reclamation's discretion (e.g., PacifiCorp's dams, off-Project water users).

While in general, the proposed action results in Klamath River flows that are lower than the natural hydrograph, there are exceptions. For example, the proposed action reduces fall releases from Link River Dam to accelerate refill of UKL causing UKL elevations to meet or exceed flood threshold elevations earlier than would have naturally occurred in some years, which would increase flow in the Klamath River in the winter. As another example, the proposed action reduces spring releases from Link River Dam to increase UKL storage for enhancement of late summer and early fall flows in the Klamath River in below average water years, which would result in higher Klamath River flows than the natural hydrograph.

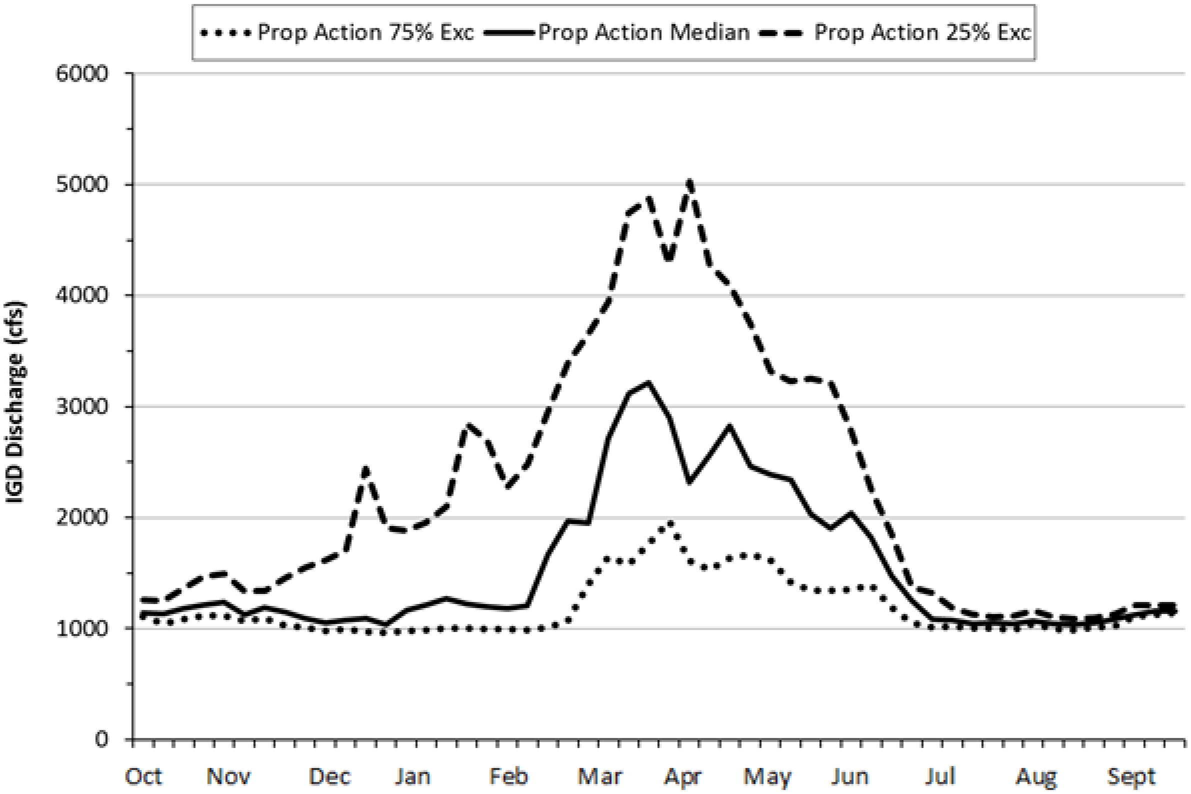


Figure 11.6. Proposed action weekly average Klamath River discharge at IGD. Weekly average flows were calculated for water years 1981-2011.

EWA volumes combined with accretions downstream of Link River Dam define the volume of water released at IGD. To test whether the EWA volume allocations reflect natural hydrological conditions, NMFS evaluates whether the EWA volumes proposed by Reclamation are representative of three key indicators of current and future hydrologic conditions in the upper Klamath Basin: 1) UKL net inflow, 2) Williamson River inflow, and 3) Natural Resources Conservation Service (NRCS) UKL inflow forecast. EWA volume has a strong positive relationship with all three indicators of hydrologic conditions as illustrated in Figures 11.7, 11.8 and 11.9. The relationship between EWA volume and the three hydrologic indicators ensures that spring and summer flows in the mainstem Klamath River reflect hydrologic conditions in the upper Klamath Basin. Specifically, wetter hydrologic conditions in the upper Klamath Basin result in larger EWA volumes and consequently, higher spring and summer flows in the mainstem Klamath River. Whereas drier hydrologic conditions in the upper Klamath Basin result in smaller EWA volumes and consequently, lower spring and summer flows in the mainstem Klamath River. The relationship between EWA volume and March through September total UKL net inflow has an R^2 value of 0.9585 (Figure 11.7). The relationship between EWA volume and March through September total Williamson River inflow has an R^2 value of 0.9605 (Figure 11.8). The relationship between EWA volume and NRCS March through September UKL inflow forecast has an R^2 value of 0.778; a lower R^2 value due to forecast error, yet still a very strong relationship (Figure 11.9).

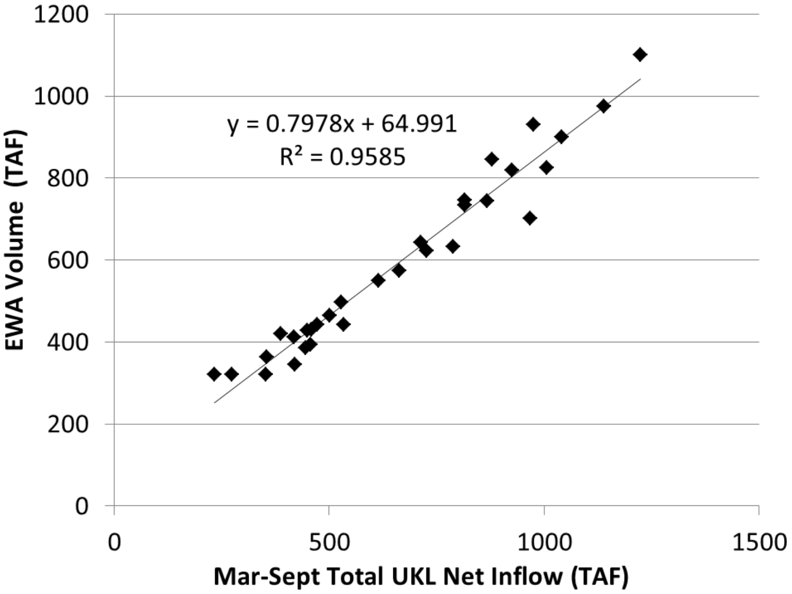


Figure 11.7. Regression between EWA volume allocation and total March through September UKL net inflow volume.

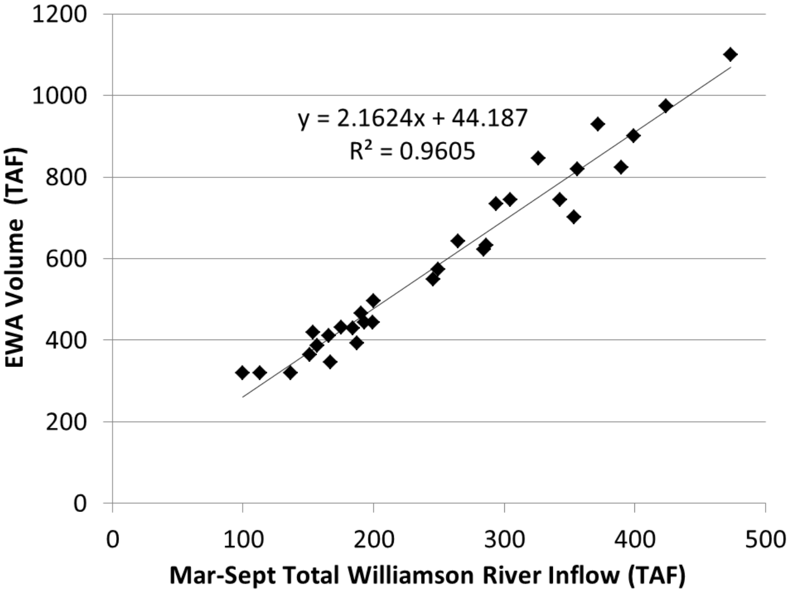


Figure 11.8. Regression between EWA volume allocation and total March through September Williamson River inflow volume.

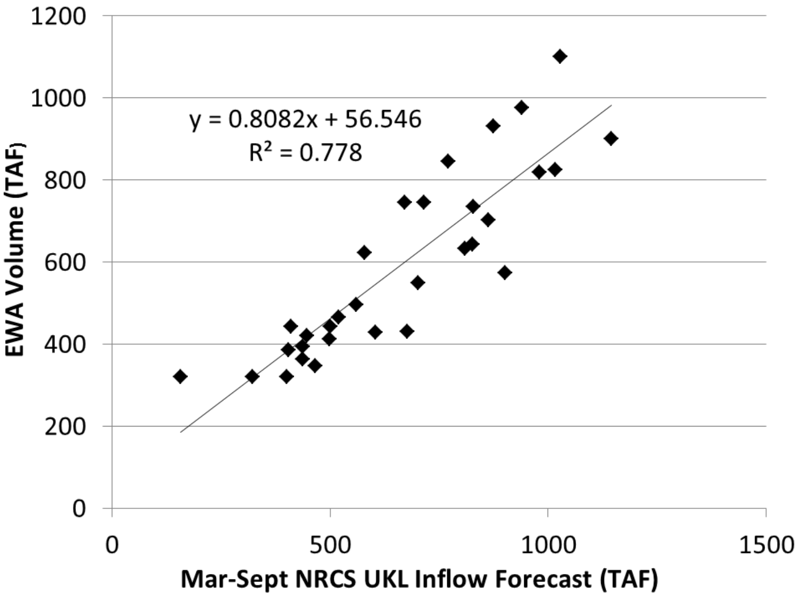


Figure 11.9. Regression between EWA volume allocation and March through September NRCS reconstructed UKL inflow forecast volume.

11.4.1.1.2 Annual Hydrograph

When compared to the observed Keno hydrograph for the POR, the proposed action hydrograph at Keno trends towards the historic Keno hydrograph from 1905-1913 (Figure 11.4). When compared to the POR, peak flows under the proposed action will occur approximately two weeks closer to the historic peak flow at Keno (Figure 11.4). Overall, under the proposed action, water will be shifted from the fall and winter period to the spring and summer period resulting in enhanced spring flows, a more gradual receding limb of the hydrograph, and enhanced summer base flows compared to the observed POR hydrograph (Figures 11.4 and 11.5). This redistribution of water is important because the proposed action ultimately shifts more water to the critical spring and summer period for life history stages of coho salmon than observed in the POR. Consequently, the proposed action hydrograph at IGD trends towards the natural flow regime relative to the observed hydrograph at IGD for the POR, however both the proposed action and observed hydrographs have been reduced relative to the natural hydrograph (Figures 11.4 and 11.5).

Compared to the observed hydrograph for the POR at IGD, flows under the proposed action begin lower in the fall and winter period, peak later in the spring, and maintain higher flows during the spring and summer period (Figure 11.5). Additional patterns evident under the proposed action are enhanced flow variability in fall and winter, and increased spring and summer flows during the descending limb of the hydrograph relative to the POR (Figure 11.5 and Appendix E). To illustrate these patterns also exist on an annual basis, NMFS compares the proposed action flows at IGD to the observed flows at IGD from March 2010 through September 2011 (Figure 11.10). In October through February 2011, the proposed action results in increased flow variability and magnitude below IGD. Additionally, the proposed action results in a higher peak flow, higher spring flows through the descending limb of the hydrograph, and enhanced flow variability and volume through the summer period (Figure 11.10).

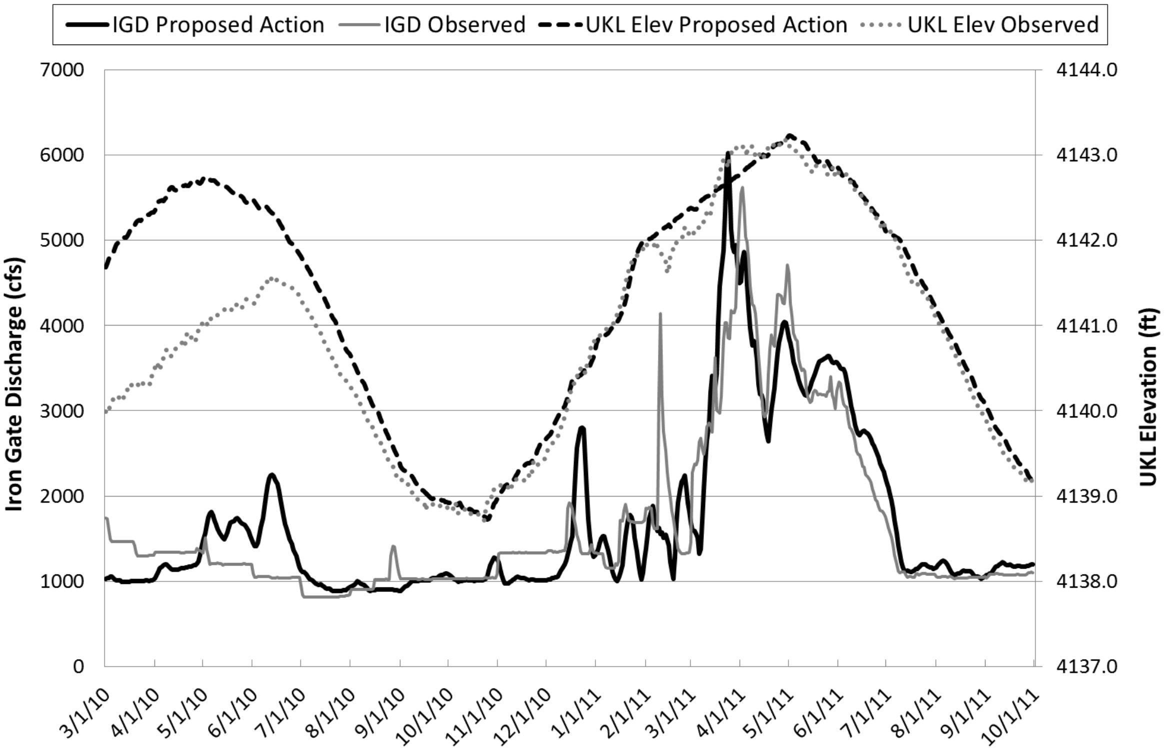


Figure 11.10. Proposed action and observed IGD discharge and UKL elevation since NMFS 2010 Biological Opinion was implemented. Proposed action IGD daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

The resultant changes to the 2010-2011 proposed action hydrograph described here, are in part, due to a higher UKL elevation on March 1, 2010 and thus, a greater UKL Supply (Figure 11.10). Based on WRIMS modeling, implementing the proposed action results in a higher UKL elevation at the end of February 2010, as well as in most years (Figure 11.11), which in turn results in enhanced mainstem Klamath River spring flows during a critical time period for coho salmon relative to observed flows for the POR.

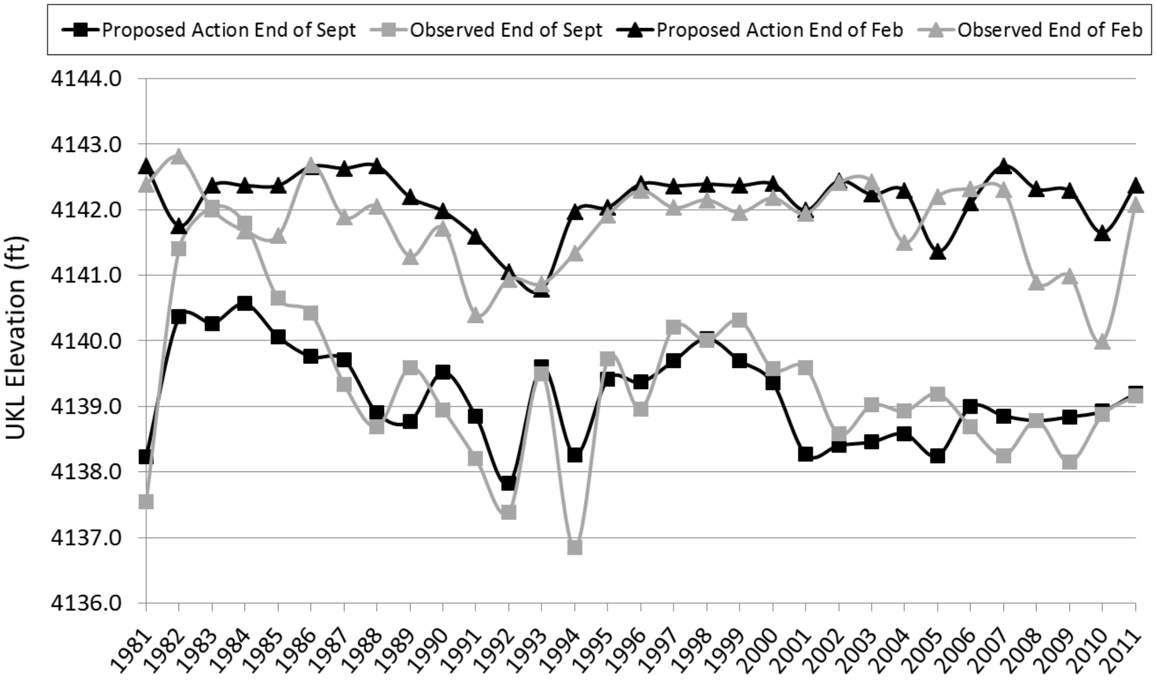


Figure 11.11. Proposed action and observed end of September and end of February UKL elevations for water years 1981-2011.

11.4.1.1.3 Flow Variability

The proposed action includes a formulaic approach to enhance flow variability relative to past operational approaches. However, the proposed action will continue to contribute to diminished flow variability relative to a natural Klamath River flow regime (e.g., reduction of incremental increases of fall and winter base flows). Given the network of dams and operational constraints of managing flow through multiple reservoirs, achieving relatively unimpaired flow variability is not feasible.

The early spring period of March and April is generally a period of high flow variability in the Klamath River. Water storage in UKL and PacifiCorp hydroelectric reservoirs generally peaks in these months. Rainfall events and sudden increases in snowmelt can result in variable flows at IGD as Reclamation and PacifiCorp treat hydrological fluctuations as run-of-the-river. However, in recent years (e.g., 2001-2005) during dry winter and spring conditions, minimum monthly flows have been implemented, and flow variability has been reduced at IGD even during March and April. The effects of the proposed action on flow variability will be greatest proximal to IGD and diminish longitudinally, as tributary accretions contribute to the volume of water and impart additional flow variability. By early April, contributions from the Shasta River are expected to be reduced by water diversions for agricultural practices, and tributaries provide relatively minor contributions for approximately 47 river miles at which point the Scott River increases flow variability. By mid-June, as Scott River flows decrease substantially from water diversions and lack of snowmelt, the loss of flow variability at IGD will be evident throughout the Upper Klamath River reach. With a strong likelihood that current climatological trends and warm spring conditions continue over the ten-year action period (Hamlet et al. 2005, Regonda et al. 2005, Stewart et al. 2005, Knowles et al. 2006, Meehl et al. 2007, Mayer and Naman 2011), NMFS anticipates early peak flows and reduced late spring accretions from the snowmelt driven Scott River watershed.

In previous consultations on Reclamation's Project, the ability to model and evaluate the range of daily flow variability has been constrained to monthly or biweekly time-step output. Under the proposed action, IGD flows are a result of daily calculations described in detail in the proposed action section and incorporate several key indicators of natural hydrologic conditions (Williamson River flow, UKL storage, accretions below Link River Dam, etc.). NMFS evaluated the daily change in flow at IGD under the proposed action versus the observed daily change in flow observed at IGD for the POR to evaluate whether the proposed action will result in a trend of the Klamath River hydrograph towards, or away from, the natural flow regime in terms of flow variability.

Each daily flow change of 30 cfs and higher was enumerated as a flow change likely to occur under the proposed action because 30 cfs is the smallest incremental flow change that NMFS reasonably expects to be implemented due to PacifiCorp's operational constraints (Hemstreet 2013). For the POR, 4,487 days out of 11,322 days (40 percent) demonstrate a change in daily flow of 30 cfs or higher under the proposed action, compared to 3,295 days out of 11,322 days (29 percent) for observed (Table 11.6). On an annual basis by water year, the percentage of days exhibiting daily flow changes of 30 cfs and higher is greater most years under the proposed action (Figure 11.12). The extent of variability is distributed relatively equally between the October through February and March through September time periods (Table 11.6).

Table 11.6. Percentage of days exhibiting daily flow changes of at least 30 cfs for the proposed action and observed discharge at IGD.

Daily Flow Change	**TIME PERIOD**		
	Water Year	**Oct-Feb**	**Mar-Sep**
Proposed Action	40%	38%	41%
Observed	29%	27%	30%

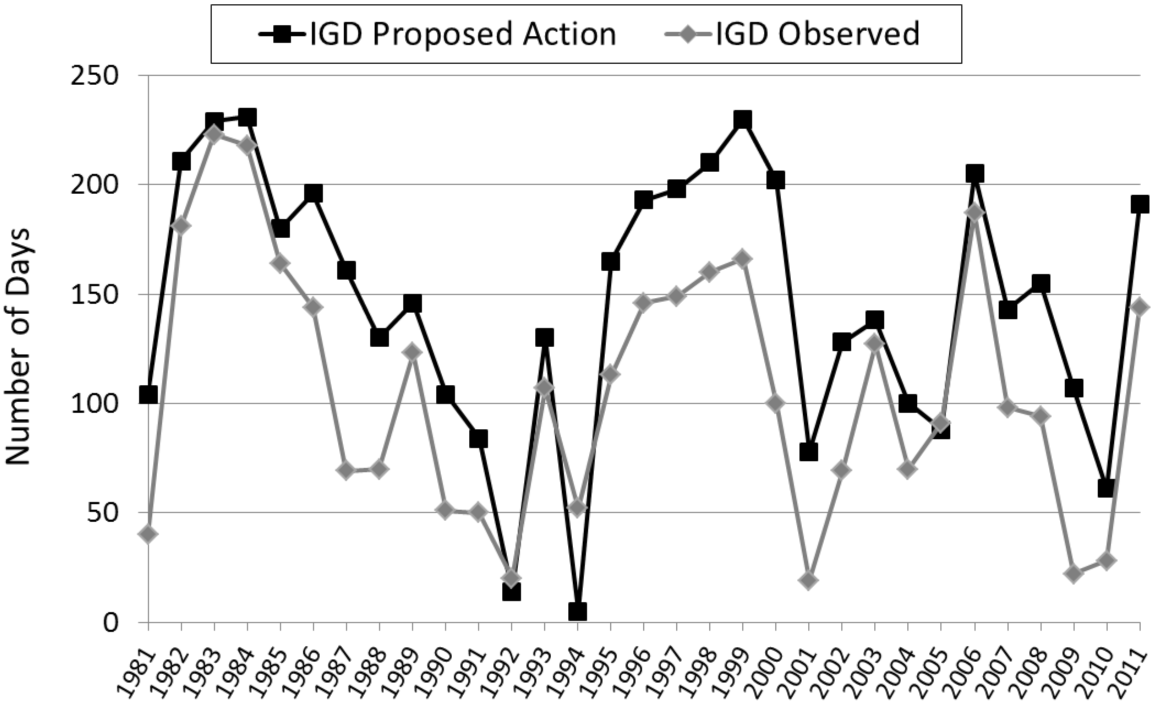


Figure 11.12. Number of days per water year that exhibit daily flow changes of 30 cfs or higher for the proposed action and Observed IGD daily discharge.

In water years 1994 and 2005, the observed IGD discharge exhibits daily variability of 30 cfs or higher for a larger number of days. However, in these years, the variability demonstrated in the observed daily discharge is often a result of management decisions and is unrepresentative of hydrologic conditions, as evidenced by the Williamson River hydrograph in water year 1994 (Figure 11.13). The Williamson River is a reasonable indicator of hydrologic conditions in the upper Klamath Basin. Although affected by water diversions above UKL by off-project water users in the spring and summer, the Williamson River still maintains a very strong correlation with UKL net inflow (Garen 2011). Water year 1994 is one of the driest years on record and yet the observed IGD flows were highest during the October through January period when the Williamson River was at base flow (Figure 11.13). Observed flows at IGD from March through June 1994 were among the lowest flows of the year, whereas observed flows at the Williamson River indicate this time period is when flows should be highest. In water year 1994, the greatest variability and some of the highest flows in the observed IGD discharge occur in the summer months when Williamson River flows are receding to base flow and natural variability is minimal (Figure 11.13). The proposed action hydrograph more accurately represents natural hydrologic conditions as it more closely mimics the shape and relative magnitude of the Williamson River hydrograph (Figures 11.13 and 11.15). Proposed action flows are dictated by daily calculations based on hydrologic indicators in the basin including the Williamson River. Although the proposed action has less daily flow changes of 30 cfs or higher than the observed flows in 1994, the variability coincides with changing hydrologic conditions and is more representative of the Klamath River natural flow regime, which is beneficial to coho salmon (Figure 11.13).

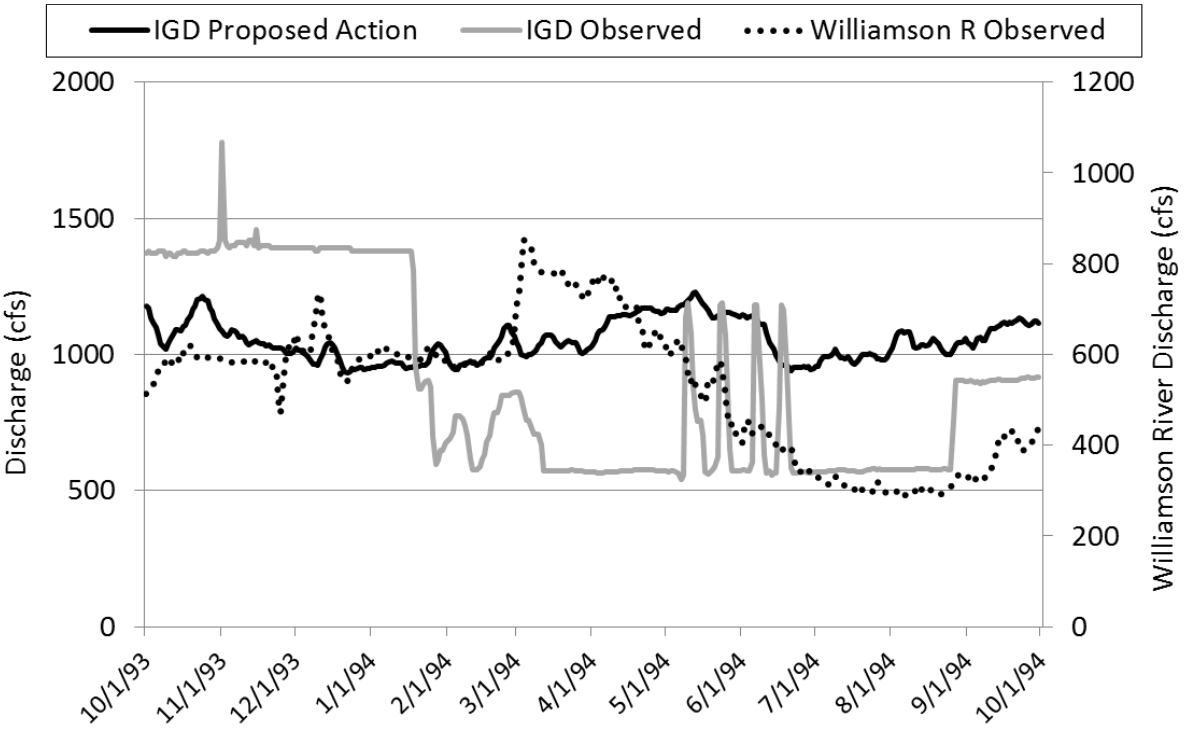


Figure 11.13. Williamson River observed, proposed action and Observed IGD discharge for water year 1994. Proposed action IGD daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

NMFS also evaluated the effect of the proposed action on flow variability by calculating and comparing the monthly coefficient of variation of IGD daily flows between the observed hydrograph and the proposed action hydrograph. The coefficient of variation is a common measure to quantify variability of a distribution and is particularly useful for comparison of data sets with different means, yet is only useful when applied to individual years. As an illustration, NMFS presents the coefficient of variation of IGD daily flows by month, for water year 2011 (Figure 11.14). The coefficient of variation for the proposed action IGD flows is greater than observed in 8 of the 12 months (Figure 11.14).

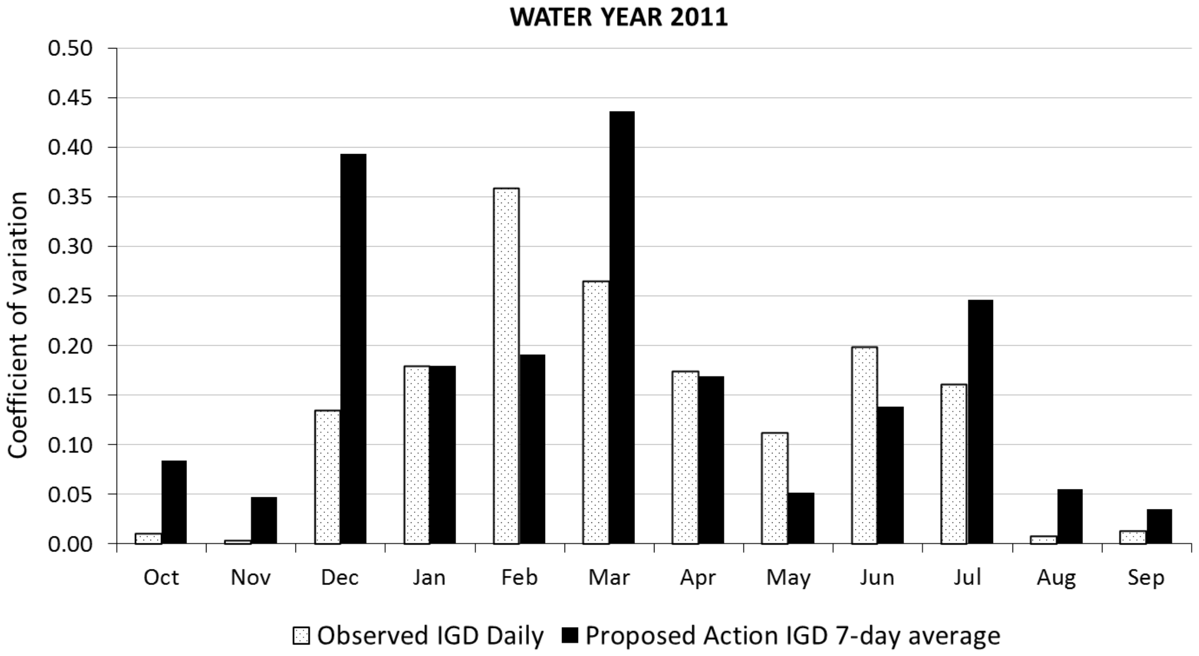


Figure 11.14. Monthly coefficient of variation comparison between proposed action and Observed IGD discharge for water year 2011. Proposed action IGD daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

Based on the results, the monthly coefficient of variation is higher for the observed hydrograph in February, and April through June. Flow variability is greater in February because of the relatively large flow event that occurred as a result of the implementation of the Fall/Winter Flow Variability Program from the RPA of NMFS (2010a). A 5,000 cfs peak flow event was released at IGD to provide a geomorphic flow that had not occurred in the past 4.5 years to address disease. The engineered event was a result of management decisions and did not reflect natural hydrologic conditions at the time, yet resulted in a higher coefficient of variation for the month of February.

In April through June, the coefficient of variation is higher for the observed daily discharge data primarily because the proposed action daily discharge data is based on a 7-day average which effectively mutes some of the daily variability. The 7-day average better represents the variability expected under implementation of the proposed action due to operational constraints. However, the 7-day average likely underestimates the daily variability experienced under spill conditions that generally occur in the spring period. When spill occurs in real-time operations, NMFS expects the proposed action IGD flows to reflect run-of-river natural daily variability.

Rapid declines in IGD flow influence flow variability. For example, in June 2011, the coefficient of variation for the observed IGD discharge is greater than the coefficient of variation for the proposed action (Figure 11.14). However, as evidenced in Figure 11.15, the variability in observed IGD discharge is in the form of a more rapid rate of decline to base flow, resulting in greater variability and a higher coefficient of variation. Figure 11.15 illustrates the receding limb of the observed hydrograph is steeper than both the observed Williamson River hydrograph and the modeled flows under the proposed action. In summary, the proposed action ensures the IGD hydrograph will approximate the natural flow variability because the calculations are based on actual real-time measurements of several hydrologic indicators including Williamson River flow.

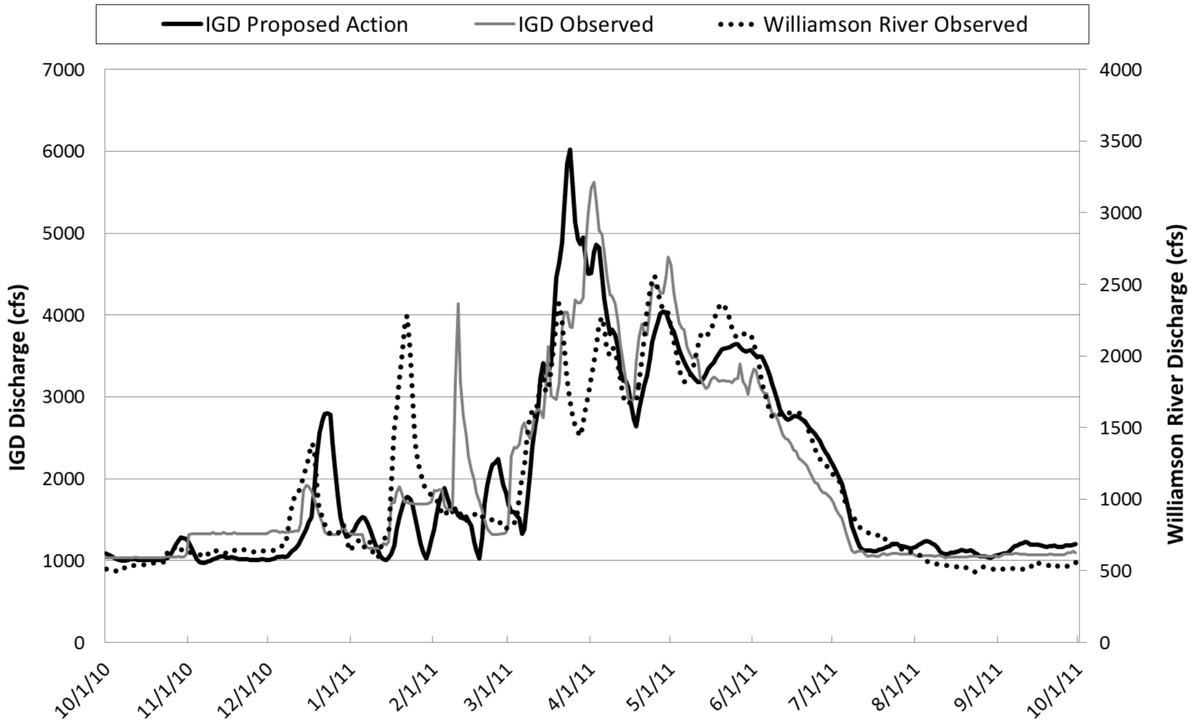


Figure 11.15. Williamson River observed, proposed action and Observed IGD discharge for water year 2011. Proposed action IGD daily discharge was calculated for water years 1981-2011 based on a 7-day moving average.

11.4.1.1.4 Channel Maintenance Flows

The role of channel maintenance flows in managed river systems to maintain the integrity and ecology of ecosystems and aquatic organisms and to facilitate sediment transport has been widely recognized (Petts 1996; USFWS and HVT 1999; Bunn and Arthington 2002; Poff et al. 2009; NMFS 2010a). NMFS believes that over-bank flows are critical in creating and maintaining in-channel and riparian habitat. In contrast, protracted drought conditions without supplemental channel maintenance flows will result in extended periods of low velocity flows and additional fine sediment deposition downstream from IGD (Holmquist-Johnson and Milhous 2010). Protracted droughts can cause spawning gravels to become filled with fine sediment and provide habitat conditions conducive to the establishment of aquatic vegetation, two conditions that are favorable to the spread of *C. shasta* in the Klamath River Basin (Stocking and Bartholomew 2007).

NMFS evaluated the effects of the proposed action on flood frequency relative to the POR to evaluate whether the proposed action will result in a trend of the Klamath River hydrograph towards, or away from, the natural flow regime in terms of channel maintenance flows (Table 11.7). Flood frequency analyses applying the Log-Pearson Type III distribution were performed on the observed daily discharge and the modeled proposed action daily discharge for the POR at

IGD. The proposed action modeled daily discharge at IGD was not converted to a 7-day moving average for the flood frequency analysis based on recent clarifications that Reclamation made to ensure implementation of the proposed action modeled daily peak flows (Reclamation 2013b). The 7-day moving average may also decrease peak magnitudes that would occur under spill conditions because large, less frequent overbank flows (e.g., >10,000 cfs) are generally run-of-river and out of Reclamation and PacifiCorp's control.

Holmquist-Johnson and Milhous (2010) identified a flow range of 2,500 to 8,700 cfs during a period of days that would initiate flushing of fine sediments in the Klamath River, given the upper ranges of flows are achieved. Higher discharge is needed to mobilize the river bed (Holmquist-Johnson and Milhous 2010; Reclamation 2011b). Holmquist-Johnson and Milhous (2010) identified flows of 11,250 or greater in order to mobilize armored substrates, while Reclamation (2011b) estimated flows between 8,400 to 10,700 cfs are needed to mobilize armored substrates in the mainstem Klamath River between Bogus Creek and the Shasta River. Based on the research (Holmquist-Johnson and Milhous 2010), NMFS identifies 5,000 cfs as the desired minimum flow magnitude to flush fine sediments.

Compared to the observed POR, the proposed action will generally increase the magnitude and frequency of channel maintenance flows (Table 11.7). For example, the proposed action is expected to increase the magnitude of the 2-yr flood when compared to the observed POR (i.e., 5,454 for the proposed action vs. 5,168 cfs observed). However, the proposed action is also expected to decrease the duration of channel maintenance flows between 5,000 and 10,000 cfs compared to the observed POR. For example, the proposed action results in 561 days with flows between 5,000 and 10,000 cfs compared to 673 days for the observed POR (i.e., a reduction of 17 percent relative to the POR). Under the proposed action, the number of days with modeled flows between 5,000 and 10,000 cfs will be reduced by an average of 7 days per year. In addition, Reclamation (2012) found that the proposed action will result in 355 days of flows between 6,000 and 12,000 cfs, while the observed POR had 461 days (i.e., a reduction of 23 percent relative to the POR). Due to the proposed action's reduction in duration of channel maintenance flows between 5,000 and 10,000 cfs compared to the observed POR and the observed POR's reduction in duration of channel maintenance flows between 5,000 and 10,000 cfs relative to the natural hydrograph (Figure 11.4), NMFS expects the proposed action will reduce the duration of channel maintenance flows between 5,000 and 10,000 cfs relative to the natural hydrograph. NMFS also expects the proposed action will reduce the magnitude and frequency of all peak flows less than 10,000 cfs relative to the natural hydrograph when storage capacity is not a limiting factor.

The proposed action is likely to result in minimal reductions to the magnitude, frequency and duration of large, less frequent flood events (e.g., >10,000 cfs) relative to the natural hydrograph. Hardy et al. (2006) concluded that the combined effect of Reclamation's Project, the network of Klamath River reservoirs, and limited storage capacities in the upper Klamath Basin maintained the likelihood of experiencing adequate overbank flows that provide riverine restorative function.

Table 11.7. Flood frequency analysis on Klamath River for IGD gaging station observed daily discharge and proposed action daily discharge for the period of record from 1981-2011.

Flood Frequency	IGD Gaging Station Discharge (CFS)	
	Observed Daily	**Proposed Action Daily**
1.5-yr Flood	3,712	3,958
2-yr Flood	5,168	5,454
5-yr Flood	9,710	10,160
10-yr Flood	13,390	14,040
25-yr Flood	18,740	19,800
50-yr Flood	23,210	24,700
100-yr Flood	28,060	30,120

11.4.1.1.5 Summary

The proposed action results in a hydrograph that approximates the shape of the natural flow regime. However, partly as a result of operating the Project, the Klamath River annual flow volume, magnitude, duration, flow variability and channel maintenance flows are reduced relative to the natural hydrograph defined by the 1905-1913 discharge dataset at Keno, Oregon (Figure 11.4). Under the proposed action, Klamath River will have lower base flows in the fall and winter, lower and earlier peak discharge, reduced spring and summer discharge, and an earlier return to base flow relative to the natural hydrograph (Figure 11.4). Spring and summer flows in the mainstem Klamath River (i.e., EWA volume) have a strong positive relationship with hydrologic conditions in the upper Klamath Basin defined by the three hydrologic indicators: UKL net inflow, Williamson River inflow, and NRCS UKL inflow forecasts. The relationship between EWA volume and the three hydrologic indicators ensures that spring and summer flows in the mainstem Klamath River reflect hydrologic conditions in the upper Klamath Basin.

Under the proposed action, Klamath River flows will have lower base flows and enhanced flow variability in the fall and winter period compared to the observed hydrograph for the POR (Figures 11.5 and 11.10). The spring peak discharge under the proposed action will generally occur two weeks later than the observed POR. Additionally, compared to the POR, the proposed action will have increased spring and summer discharge volume and a later return to summer base flow (Figures 11.4, 11.5 and 11.10). Therefore, the proposed action hydrograph at IGD trends towards the natural flow regime compared to the observed hydrograph at IGD for the POR; however, both hydrographs have been reduced relative to the natural hydrograph (Figures and 11.4 and 11.5).

The proposed action ensures daily variability will occur at IGD if variability exists naturally in the basin. The proposed action hydrograph generally tracks daily changes in natural hydrologic conditions and implementation of the proposed action is expected to result in enhanced flow variability throughout the year relative to the POR (Figure 11.10 and Table 11.6). While the proposed action enhances flow variability relative to past Project operations, the proposed action will continue to contribute to diminished flow variability relative to a natural Klamath River flow regime.

The results from Table 11.7 indicate that the likelihood of experiencing large, infrequent overbank flows under the proposed action is generally consistent with the observed POR. Hardy et al. (2006) concluded that the combined effect of Reclamation's Project, the network of Klamath River reservoirs, and limited storage capacities in the upper Klamath Basin maintained the likelihood of experiencing adequate overbank flows that provide riverine restorative function. Reclamation does not propose substantive changes to the approach to storing water analyzed by Hardy et al. (2006) such that NMFS would expect changes to the magnitude, frequency and duration of overbank flood events above 10,000 cfs in the ten-year action period. Due to the proposed action's reduction in duration of channel maintenance flows between 5,000 and 10,000 cfs when compared to the observed POR and the observed POR's reduction in duration of channel maintenance flows between 5,000 and 10,000 cfs relative to the natural hydrograph, NMFS expects the proposed action will reduce the duration of channel maintenance flows between 5,000 and 10,000 cfs relative to the natural hydrograph. NMFS also expects the proposed action will reduce the magnitude and frequency of all peak flows less than 10,000 cfs relative to the natural hydrograph when storage capacity is not a limiting factor.

11.4.1.2 Effects to Essential Habitat Types

The proposed action's hydrologic effects have the potential to affect the following three essential habitat types that are found within designated coho salmon critical habitat in the action area: spawning areas, rearing areas, and migration corridors. The proposed action has the most hydrologic and water quality effects on the mainstem Klamath River near IGD and generally diminishes in the Seiad to Orleans reach because the proportion of flow contributed by the proposed action diminishes with distance downstream of IGD (Figure 11.16).

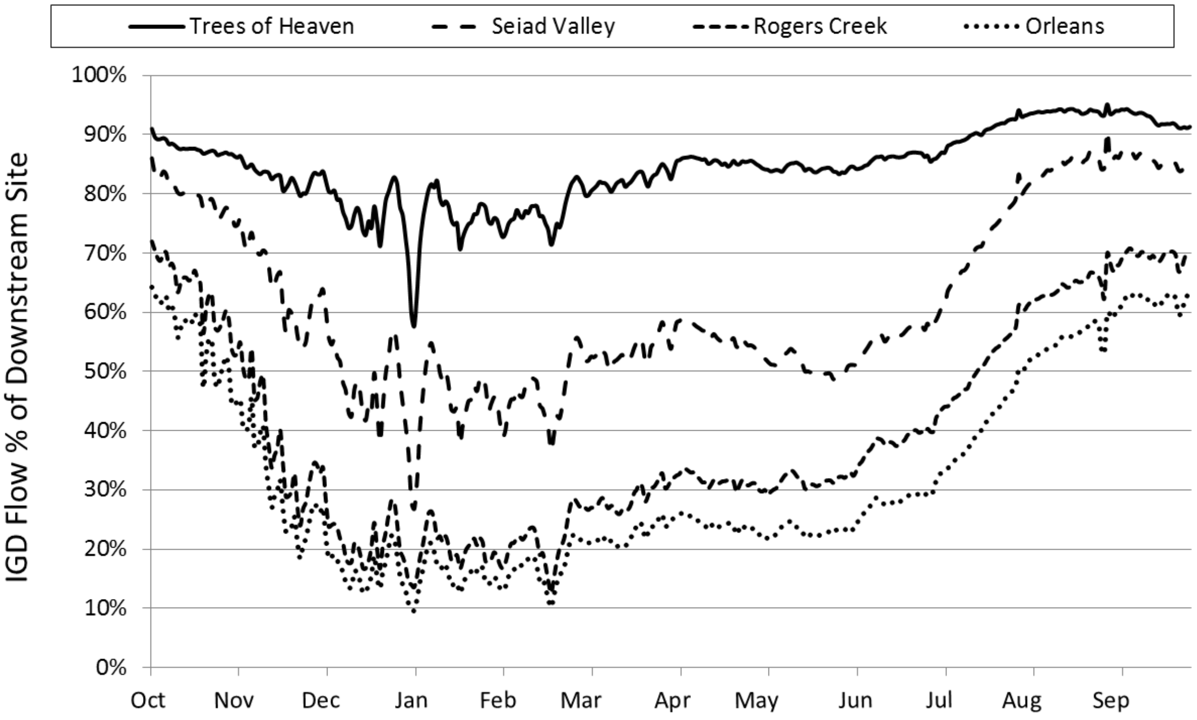


Figure 11.16. The average proportion of flow that IGD contributes to downstream sites throughout the year. Data from stream gages and accretion estimates from Reclamation.

In the *Hydrological Effects* section, NMFS recognizes Reclamation's strides to incorporate elements of the natural flow regime into the proposed action. While flow variability will be enhanced, and EWA release strategies incorporate key considerations for coho salmon, the Project consumes water and thus, diminishes flows, particularly channel maintenance and spring flows, in the mainstem Klamath River when compared to a natural hydrology.

11.4.1.2.1 Spawning Habitat

Coho salmon are predominately tributary spawners and limited coho salmon spawning occurs in the mainstem Klamath River between Indian Creek (RM 107) and IGD (RM 190), primarily in side-channels and margins of the mainstem Klamath River (Magnuson and Gough 2006). Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation. As discussed in the *Hydrologic Effects* section, the proposed action will reduce the magnitude, frequency and duration of flows between 5,000 and 10,000 cfs relative to the natural hydrograph. Because of storage limitations, the proposed action will likely have minimal reductions to the magnitude and frequency of flows above 10,000 cfs relative to the natural hydrograph. Therefore, the reduction in magnitude, frequency and duration of channel maintenance flows under the proposed action will likely reduce mobilization of fines from spawning gravel. However, the proposed action is not likely to result in armoring of spawning gravel because the proposed action will have minimal reductions to the magnitude and frequency of flows above 10,000 cfs relative to the natural hydrograph. Therefore, the proposed action is likely to reduce some quality of spawning habitat when spawning gravel becomes filled by fines over time.

Model results in the Phase II report (Hardy et al. 2006) for Chinook salmon spawning habitat indicate that the IGD to Shasta River reach has at least 80 percent of maximum available spawning habitat when flows are between 950 and approximately 2600 cfs. While Chinook and coho salmon spawning habitat preferences (e.g., velocity depth, substrate) vary, coho salmon spawning habitat preferences fall within the range of conditions selected by Chinook salmon. Given the abundance of Chinook spawning habitat when flows at IGD are 950 cfs or above and the low numbers of adult coho salmon spawning in the mainstem, NMFS expects that the quantity of coho salmon spawning habitat will be suitable under the proposed action.

In average and wetter years (≤45 percent exceedance; Table 11.8), flows under the proposed action are expected to incrementally increase through the fall/winter period with increased flow variability. Though spawning habitat for coho salmon is not limited in the mainstem Klamath River, an increase in flows and flow variability during fall and winter will increase spawning habitat. As flows increase, suitable spawning habitat becomes more available close to the river margins. Spawning habitat closer to the margins has a lower risk of scouring during peak runoffs than locations further towards the middle of the river. In addition, variable flows result in different areas of the channel bed with high quality spawning habitat for coho salmon, which increases spawning habitat throughout the fall/winter period. Therefore, the proposed action is likely to increase the quantity of spawning habitat in the mainstem Klamath River in relatively wet years when IGD flows are variable and incrementally increase during the late fall and winter.

Table 11.8. Exceedance table for proposed action daily average flows (cfs) at Iron Gate Dam.

	Oct	Nov	Dec	Jan	Feb
95%	1018	1001	947	951	961
90%	1031	1012	953	957	968
85%	1048	1022	962	964	975
80%	1069	1034	968	974	984
75%	1083	1047	977	985	995
70%	1098	1068	986	997	1017
65%	1119	1088	995	1028	1041
60%	1142	1104	1008	1069	1099
55%	1163	1127	1023	1144	1198
50%	1181	1159	1050	1200	1334
45%	1199	1195	1134	1312	1632
40%	1220	1237	1283	1488	1951
35%	1260	1304	1448	1634	2217
30%	1298	1355	1616	1854	2449
25%	1337	1437	1755	2175	2680
20%	1406	1490	2037	2589	3100
15%	1485	1574	2483	3083	3837
10%	1553	1651	3106	4164	4857
5%	1674	2509	4259	5133	6624

11.4.1.2.2 Adult and Juvenile Migration Corridor

The proposed action will affect water depth and velocity in the mainstem Klamath River, which may affect fish passage. The proposed action will lower flows in the mainstem Klamath River during much of November and December. However, the November and December flows of at least 950 cfs under the proposed action will provide the depth and velocity for coho salmon migration, and thus, are not expected to impede adult migration. In addition, the proposed action does retain some aspects of a natural flow regime through flow variability, which will provide adult coho salmon migration cues commensurate with natural hydrologic conditions.

The juvenile migration corridor within the mainstem Klamath River is also expected to be suitable at flows of at least 900 cfs. Navigating shallow channel sections is easier for juvenile coho salmon than adult salmon due to their smaller size. Juvenile coho salmon have also been observed migrating from the mainstem Klamath River into tributaries at times when IGD flows have been less than 1,300 cfs and tributary base flows are at summer low levels (Soto et al. 2008). The proposed action's effects on the migration corridors of juveniles entering tributaries are dependent on both the alluvial features at those sites and mainstem and tributary flows.

Sutton and Soto (2010) documented several Klamath River tributaries (i.e., Cade [RM 110] and Sandy Bar [RM 76.8] creeks) where fish access into the creeks was challenging, if not impossible, when IGD flows were 1000 cfs in the summer. Because of their alluvial steepness, NMFS acknowledges that some tributaries (e.g., Sandy Bar Creek) may not be conducive to access until flows are very high, which may not be possible in the summer even without the proposed action. Stage height-flow relationship data at mainstem Klamath River gage sites (e.g., Seiad or Orleans), indicate that during low summer flow conditions, 100 cfs influences the Klamath River stage height by 0.1 to 0.13 feet. Given the minimal effect on stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries.

11.4.1.2.3 Rearing Habitat

Rearing areas provide essential features such as cover, shelter, water quantity, and space. The following discussion on the effects of the proposed action on rearing habitat is best categorized by the affected essential features of critical habitat, which include cover, shelter, space, and water quality. Cover, shelter, and space are analyzed together as habitat availability. Specific areas of rearing habitat most influenced by flow include side channels and floodplain access, which have greater opportunity to become inundated under a natural hydrology. NMFS also evaluates the efficacy of channel maintenance flows on coho salmon critical habitat.

11.4.1.2.3.1 Coho Salmon Fry

As discussed in the *Environmental Baseline* section, coho salmon fry are present in the mainstem Klamath River from March to approximately mid-June (Justice 2007). Therefore, effects to coho salmon fry habitat are only addressed for the March through mid-June period. The proposed action reduces flow volume in the mainstem Klamath River generally throughout most of the year. Therefore, NMFS assumes that in locations where there are positive relationships between flow and habitat, the proposed action reduces habitat availability (Figure 11.17). While NMFS' ability to quantify proposed action effects are confounded, NMFS expects the range of proposed action effects resulting from flow reductions on mainstem Klamath River coho salmon fry habitat availability will vary considerably, from having no effect to levels that NMFS considers adverse.

Between IGD and the Shasta River (RM 176), habitat for coho salmon fry increases as flows increase from 1000 cfs to 4,100 cfs. However, for the purpose of analyzing effects of the proposed action on coho salmon and their critical habitat, NMFS focused its analysis on those conditions when habitat availability is less than 80 percent of maximum available. As described in the *Flow and Rearing Habitat Analysis* section (i.e., section 11.1.3), when habitat availability is at least 80 percent of maximum, the proposed action is not expected to adversely affect the function of essential features of coho salmon critical habitat. The proposed action generally lowers flows, and therefore habitat is generally reduced from IGD to the Shasta River when flows range from 1000 cfs to 2,350 cfs (Figure 11.17). Using the same logic for the downstream reaches, NMFS assumes that when the proposed action contributes to mainstem flows of approximately 1,000 to 3000 cfs at the mouth of the Shasta River (RM 176), coho salmon fry habitat decreases between the Shasta and Scott rivers. Between the Scott and Salmon Rivers, coho salmon fry habitat availability decreases when the proposed action contributes to mainstem flows of approximately 1000 to 2500 cfs and 4550 and 5950 cfs at the Scott River mouth (RM 143; Figure 11.17). The steeper the relationship between flow and percent of maximum habitat, the extent of habitat reduction becomes greater (Figure 11.17).

To summarize the proposed action's effects on coho salmon fry habitat availability, NMFS developed an exceedance table for the proposed action from March to June for the three mainstem reaches. The exceedance table enables NMFS to assess the frequency and timing of coho salmon fry habitat reductions caused by the proposed action. The proposed action will reduce coho fry habitat availability in the mainstem Klamath River between IGD (RM 190) to the Salmon River (RM 65.5) in below average years (≥ 60 percent exceedance), and in wet years (≥ 15 percent exceedance; Table 11.9) in June. While the actual extent of habitat reduction is not known, the habitat reduction is greatest in the IGD to Scott River reaches because the relationship between flow and percent of maximum habitat is steepest in these reaches (Figure 11.17).

While there will be reductions in habitat availability to coho salmon fry, the proposed action does provide flow variability in the mainstem Klamath River. Flow variability will occur during precipitation and snowmelt events, reflecting qualities of a natural flow regime. When hydrologic conditions in the upper Klamath Basin are wet, flow variability under the proposed action will result in higher flows in the mainstem Klamath River downstream of IGD. Temporary increases in mainstem flows are expected to result in short-term increases in the amount and quality of habitat in the mainstem for fry and juvenile coho salmon. Therefore, the adverse effects to coho salmon fry habitat in the mainstem Klamath River between IGD and the Salmon River during below average to wet years are likely to be somewhat moderated by the flow variability under the proposed action when hydrological conditions in the upper Klamath Basin are wet. When the upper Klamath Basin is experiencing relatively wet hydrologic conditions, flows in the mainstem Klamath River will be relatively high seven days later.

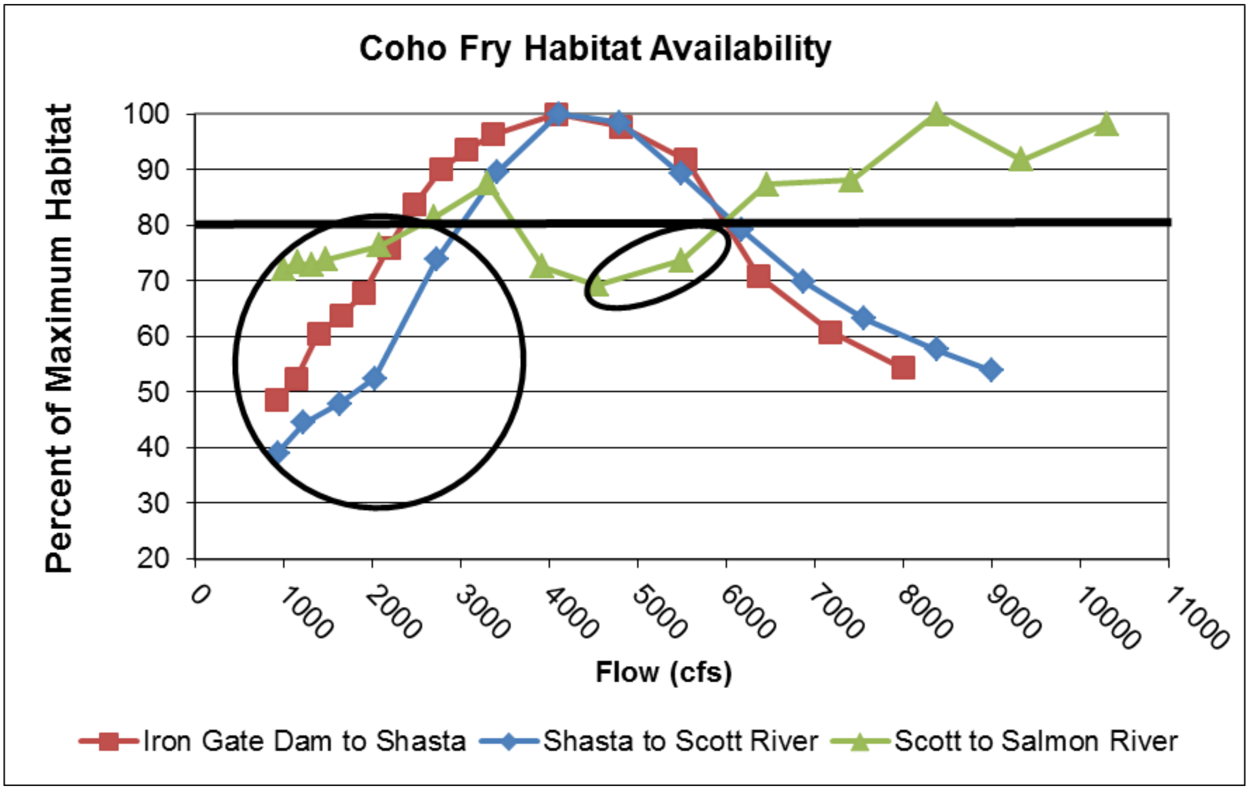


Figure 11.17. Coho salmon fry habitat availability relative to mainstem flows for three reaches downstream of IGD (Hardy 2012). Circled areas illustrate the range of flows that may reduce coho fry habitat availability. Flows are located at the upstream end of the reaches.

Table 11.9. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon fry habitat availability to below 80 percent of maximum (orange highlight).

	Iron Gate Dam to Shasta River				Shasta to Scott Rivers				Scott to Salmon Rivers			
Exceedance	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**
95%	999	1308	1173	1020	1266	1480	1317	1104	1860	2082	1894	1284
90%	1028	1324	1190	1045	1327	1543	1369	1144	2056	2296	2060	1414
85%	1105	1339	1238	1113	1430	1619	1453	1224	2261	2623	2225	1564
80%	1287	1399	1341	1166	1672	1689	1569	1283	2592	2791	2492	1685
75%	1505	1719	1436	1207	1910	1966	1756	1359	3030	3007	2814	1805
70%	1664	1853	1597	1261	2090	2135	1898	1432	3315	3343	3258	1942
65%	1812	1980	1731	1323	2245	2340	2097	1504	3633	3771	3519	2148
60%	2052	2158	1898	1384	2612	2570	2254	1585	3994	4068	3791	2362
55%	2413	2318	2055	1458	2890	2795	2492	1676	4334	4569	4071	2540
50%	2773	2549	2276	1580	3336	3091	2699	1819	5215	4945	4389	2705
45%	3048	2801	2417	1667	3674	3387	2891	1945	5678	5345	4952	3002
40%	3239	3099	2602	1804	3980	3684	3123	2102	6003	6014	5381	3341
35%	3512	3501	2894	1925	4368	4221	3451	2320	6473	6546	5961	3702
30%	3880	3873	3129	2058	4744	4567	3779	2442	7324	7100	6309	4056
25%	4369	4235	3428	2186	5250	5026	4057	2535	8196	7753	6778	4554
20%	4889	4810	3695	2409	5983	5516	4324	2896	9278	8268	7259	5157
15%	5780	5520	4192	2817	6910	6233	4902	3382	10361	8865	7801	5687
10%	6781	5964	4565	3360	7987	6778	5423	3911	11844	9686	8651	6418
5%	7585	6513	5027	3996	9086	7602	5981	4663	14036	10615	9817	8045

11.4.1.2.3.2 Coho Salmon Juvenile

As discussed in the *Environmental Baseline* section, coho salmon juveniles are present in the mainstem Klamath River throughout the year. However, the period from March to June represents the peak of coho salmon juvenile presence (Justice 2007). While coho salmon juveniles are present in the mainstem Klamath River in the summer, their habitat is limited to areas that provide suitable cooler water temperatures during this period (i.e., thermal refugia). Therefore, NMFS will analyze the proposed action's effects on coho salmon juvenile rearing habitat during spring using the Hardy et al.'s (2006) flow-habitat curves. However, NMFS will analyze the effects of the proposed action on the integrity of thermal refugia in the summer period.

As discussed earlier, the proposed action reduces flow volume in the mainstem Klamath River generally throughout the year, and the effects of flow reduction on juvenile coho salmon habitat availability in the mainstem Klamath River vary spatially and temporally downstream of IGD. The steeper the relationship between flow and percent of maximum habitat, the greater the magnitude of habitat reduction is when flows are reduced (Figure 11.18).

In the Trees of Heaven reach (RM 175), coho salmon juvenile habitat is reduced when flows range from 1,000 to 1,224 cfs and 2672 to 4449 cfs at that reach. When the proposed action contributes to mainstem flows of approximately 2083 to 3310 cfs and 5498 to 8484 cfs in the Seiad Valley reach (RM 129), coho salmon juvenile habitat is reduced. At the Rogers Creek reach (RM 72), coho salmon juvenile habitat is reduced when flows range from 900 to 10,675 cfs at that reach (Figure 11.18).

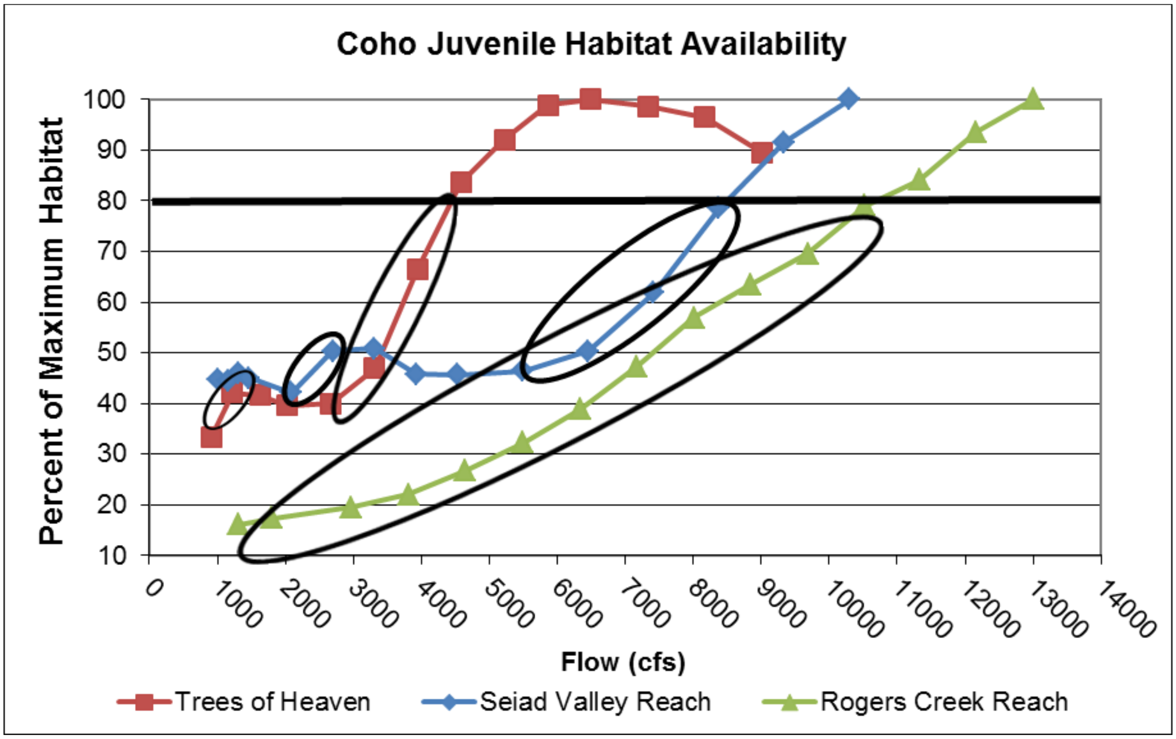


Figure 11.18. Coho salmon juvenile habitat availability for three reaches downstream of IGD. Circled areas illustrate the range of flows that may reduce coho salmon juvenile habitat availability.

The proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River between the Trees of Heaven (RM 172) to Rogers Creek (RM 72) reaches at various times of the year and at various water exceedances (Tables 11.10 to 11.12). Of the three reaches, the proposed action reduces coho salmon juvenile habitat availability in the Rogers Creek reach in most water years and in all months between October and June (Table 11.12).

Table 11.10. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Trees of Heaven reach.

	Trees of Heaven								
Exceedance	Oct	Nov	Dec	Jan	Feb	**March**	**April**	**May**	**June**
95%	1138	1201	1148	1184	1201	1266	1480	1317	1104
90%	1168	1218	1169	1209	1228	1327	1543	1369	1144
85%	1195	1240	1189	1230	1258	1430	1619	1453	1224
80%	1219	1252	1209	1256	1295	1672	1689	1569	1283
75%	1238	1265	1233	1301	1320	1910	1966	1756	1359
70%	1256	1283	1251	1341	1376	2090	2135	1898	1432
65%	1285	1302	1268	1404	1456	2245	2340	2097	1504
60%	1307	1325	1301	1455	1536	2612	2570	2254	1585
55%	1328	1347	1344	1548	1676	2890	2795	2492	1676
50%	1355	1393	1425	1690	1890	3336	3091	2699	1819
45%	1382	1430	1556	1856	2250	3674	3387	2891	1945
40%	1415	1475	1725	2098	2540	3980	3684	3123	2102
35%	1445	1551	1884	2283	2861	4368	4221	3451	2320
30%	1489	1630	2054	2533	3144	4744	4567	3779	2442
25%	1531	1685	2310	2843	3577	5250	5026	4057	2535
20%	1578	1739	2783	3322	4163	5983	5516	4324	2896
15%	1686	1844	3214	4144	5224	6910	6233	4902	3382
10%	1797	2037	3856	5308	6320	7987	6778	5423	3911
5%	1925	3371	5771	6695	8900	9086	7602	5981	4663

Table 11.11. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Seiad Valley reach.

	Seiad Valley Reach								
Exceedance	Oct	Nov	Dec	Jan	Feb	**March**	**April**	**May**	**June**
95%	1188	1349	1329	1431	1549	1860	2082	1894	1284
90%	1220	1393	1376	1574	1653	2056	2296	2060	1414
85%	1260	1420	1448	1682	1815	2261	2623	2225	1564
80%	1301	1439	1494	1771	1975	2592	2791	2492	1685
75%	1327	1459	1565	1880	2066	3030	3007	2814	1805
70%	1354	1483	1661	2012	2221	3315	3343	3258	1942
65%	1392	1514	1746	2171	2503	3633	3771	3519	2148
60%	1428	1561	1836	2356	2763	3994	4068	3791	2362
55%	1452	1606	1955	2574	2954	4334	4569	4071	2540
50%	1485	1656	2117	2757	3273	5215	4945	4389	2705
45%	1524	1712	2254	3062	3566	5678	5345	4952	3002
40%	1565	1771	2465	3354	4036	6003	6014	5381	3341
35%	1599	1851	2707	3948	4326	6473	6546	5961	3702
30%	1644	1937	3218	4618	5240	7324	7100	6309	4056
25%	1729	2022	3919	5236	6254	8196	7753	6778	4554
20%	1783	2139	4629	6164	7227	9278	8268	7259	5157
15%	1887	2340	5705	7410	8498	10361	8865	7801	5687
10%	2040	3162	7916	8907	11092	11844	9686	8651	6418
5%	2194	5885	10577	12087	16196	14036	10615	9817	8045

Table 11.12. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Rogers Creek reach.

	Rogers Creek								
Exceedance	Oct	Nov	Dec	Jan	Feb	**March**	**April**	**May**	**June**
95%	1283	1549	1771	2084	2646	3627	3320	2694	1734
90%	1382	1698	1970	2812	3130	4276	3898	3019	1924
85%	1449	1774	2193	3228	3617	4804	4592	3375	2144
80%	1524	1820	2475	3558	4109	5415	5220	3975	2371
75%	1575	1880	2751	3957	4749	5999	6180	4502	2605
70%	1619	1966	3010	4457	5428	6537	6551	5100	2844
65%	1662	2029	3313	4834	5790	7036	7031	5654	3126
60%	1705	2092	3686	5254	6185	7875	7626	6222	3427
55%	1737	2171	3999	5926	6546	9078	8268	6843	3775
50%	1789	2266	4402	6591	7123	10212	8901	7639	4221
45%	1827	2365	4818	7276	7765	10814	9848	8448	4549
40%	1859	2492	5576	7993	8702	11586	10639	9441	4941
35%	1908	2740	6416	9005	9991	12416	11578	9949	5540
30%	1987	3069	7546	10268	11867	13786	12454	10604	6242
25%	2118	3408	8902	12564	13208	15292	13273	11589	6851
20%	2304	3963	10309	14976	16133	16874	14095	12520	7646
15%	2529	5033	13624	17414	18730	18426	15015	13081	8616
10%	2740	7829	18897	20762	23843	20633	16587	14061	9990

5%	3336	13176	27664	26168	30946	23706	18311	15303	12440

As with coho salmon fry, the adverse effects to coho salmon juvenile habitat in the Trees of Heaven, Seiad Valley, and Rogers Creek reaches are likely to be somewhat moderated by the flow variability incorporated into the proposed action when hydrological conditions in the upper Klamath Basin are wet.

11.4.1.2.3.3 Water Quality

Water quality impairments in the Klamath River are most common in the late spring through summer. Therefore, NMFS narrows the water quality analysis to the spring and summer. As with most rivers, the water quality in the Klamath River is influenced by variations in climate and flow regime (Garvey et al. 2007, Nilsson and Renöfält 2008). Because climate effects are beyond Reclamation's discretion, NMFS will focus in this section (NMFS addresses climate effects in other sections of this BiOp) on the water quality effects resulting from controlled flows, which are influenced by the proposed action. Water quality analysis conducted by Asarian and Kann (2013) indicates that flow significantly affects water temperature, dissolved oxygen, and pH in the Klamath River. Multiple, complex, and interacting pathways link flow to water quality effects (Figure 11.19). In fact, of all the independent variables evaluated, Asarian and Kann (2013) found that flow had the strongest effect on water quality. Some of these water quality parameters, such as water temperature and dissolved oxygen are discussed further below.

Water Temperature

As discussed previously, the proposed action will reduce the volume of water released from IGD during the spring. Water released from IGD influences water temperature in the mainstem Klamath River, and the magnitude and extent of the influence depends on the temperature of the water being released from the dam, the volume of the release, and meteorological conditions (NRC 2004). As the volume of water decreases out of IGD, water temperature becomes more responsive to local meteorological conditions such as solar radiation and air temperature due to reduced thermal mass and increased transit time (Basdekas and Deas 2007). The proposed action's effect of reducing mainstem flows in the spring will result in longer flow transit times, which will increase daily maximum water temperatures and to a lesser extent, mean water temperatures in the mainstem Klamath River downstream of IGD during the spring (NRC 2004).

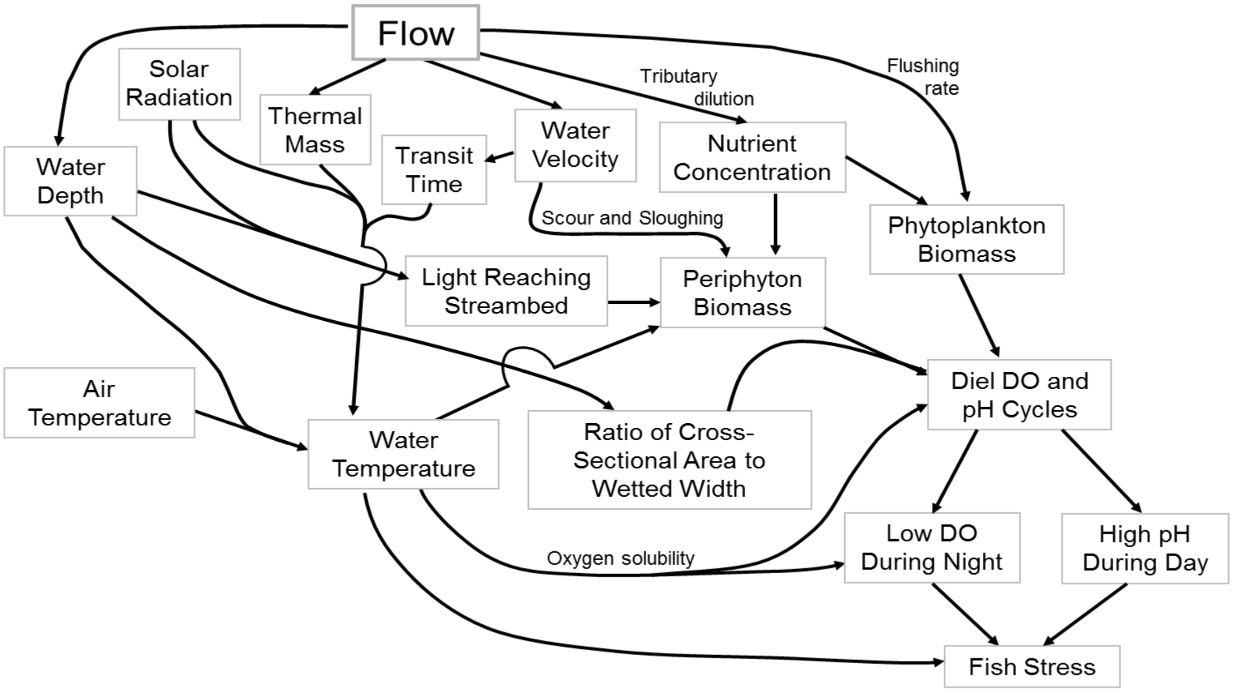


Figure 11.19. Conceptual model for the effect of flow on water quality in the mainstem Klamath River. The model only shows the most relevant factors that affect water quality (Asarian and Kann 2013).

Temperature modeling of the mainstem Klamath River by Perry et al. (2011) shows that increasing flows out of IGD by as much as 1000 cfs in the spring decreases water temperatures on the mainstem Klamath River by only up to 0.5 °C at either the Shasta River or the Scott River confluence (Appendix F). Since the total net Project reductions (i.e., the total Project diversions minus return flows) to mainstem Klamath River flows in the spring is 1,000 cfs, the proposed action is likely to increase water temperature in the mainstem Klamath River between IGD and the Scott River by up to approximately 0.5 °C during the spring. Below the Scott River mouth, the proposed action's effects on water temperature in the spring are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in the mainstem Klamath River. In the summer and early fall, any decreases in IGD flows are likely to reduce water temperature in the mainstem Klamath River because reservoir water behind IGD is warmer than mainstem Klamath River water.

Nutrients and Dissolved Oxygen

Temperature is a primary influence on the ability of water to hold oxygen, with cool water able to hold more dissolved oxygen than warm water. The proposed action's warming effect on water temperatures and longer transit times increases the probability that dissolved oxygen concentrations will decrease in the mainstem Klamath River downstream of IGD. In addition, the proposed action also indirectly affects pH and dissolved oxygen through its interactions with periphyton, algae that grow attached to the riverbed.

The proposed action results in agricultural tailwater discharges at the Lost River Diversion Canal and the Klamath Straits Drain. These discharges occur in the Link River upstream of Keno Dam, and contribute to impaired water quality conditions in the mainstem Klamath River downstream of IGD (Figure 7.5). While the Klamath Project is a net sink for nutrient load on an annual basis (Rykbost and Charlton 2001, Danosky and Kaffka 2002, ODEQ 2010), these agricultural discharges generally increase the nutrient concentration of the Keno Impoundment reach in the summer and fall (ODEQ 2010, Reclamation 2012). Nutrient concentrations decline with distance downstream due to dilution by tributaries and interception and retention within Copco and Iron Gate Reservoirs; however, enough nutrients pass through the reservoirs to still support abundant growth of periphyton in the mainstem Klamath River below IGD (USDOI and CDFW 2013). Total phosphorus will slightly increase downstream of IGD because of the increased nutrient concentrations released from the Klamath Straights Drain or the Lost River Diversion Channel in the summer and fall (Asarian 2013).

The seasonal (summer/fall) release of nutrients out of Iron Gate Reservoir stimulates periphyton growth in the mainstem Klamath River (USDOI and CDFW 2013). The NRC (2004) stated that stimulation of any kind of plant growth can affect dissolved oxygen concentration. However, because nutrient concentration is only one factor influencing periphyton growth, the small increase in nutrients may not necessarily increase periphyton growth. Other factors influencing periphyton growth include light, water depth, and flow velocity. In addition, many reaches of the Klamath River currently have high nutrient concentrations that suggest neither phosphorus nor nitrogen is likely limiting periphyton growth. Thus, an increase in nutrient concentration would not necessarily result in worse dissolved oxygen and pH conditions.

While the proposed action's increase in nutrients in the mainstem Klamath River between IGD (RM 190) and Seiad Valley (RM 129) is not likely to have a direct influence on periphyton growth, the proposed action's reduction of mainstem flows has a larger effect on periphyton and its influence on dissolved oxygen concentration. Several mechanisms are responsible for flow effects on periphyton biomass. Some of these include the relationship between flow and water temperature, water depth, and water velocity. When low flows lead to warmer water temperature, periphyton growth likely increases (Biggs 2000). High flows increase water depth, which likely reduce light penetration in the river. Conversely, low flows generally decrease water depth, which increases periphyton photosynthesis. Low water depth also disproportionally amplifies the relative water quality effects of periphyton (i.e., diel cycles of dissolved oxygen would be magnified) because the ratio between the cross-sectional area and channel width decreases (i.e., mean depth decreases). In other words, the inundated periphyton biomass[6] would have greater water quality effect on the reduced water column (Figure 11.20, Asarian and Kann 2013).

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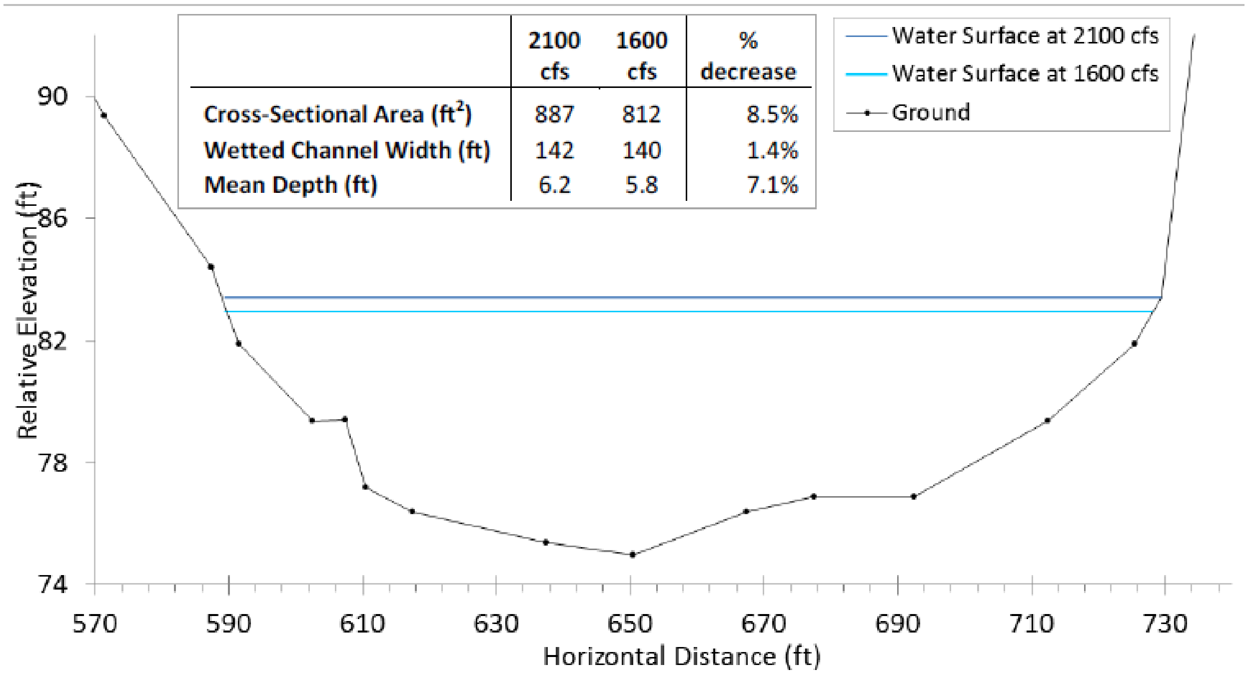
[6] Periphyton are attached to the riverbed and exert their influence on the water column chemistry by impacting diel cycles of photosynthesis and respiration in the overlying water column. Although periphyton would also decrease as the wetted channel area declines, they would decrease at a lower rate relative to water volume changes because the ratio of area:volume increases with decreased flow.



	2100 cfs	1600 cfs	% decrease
Cross-Sectional Area (ft^2)	887	812	8.5%
Wetted Channel Width (ft)	142	140	1.4%
Mean Depth (ft)	6.2	5.8	7.1%

Figure 11.20. Example Mainstem Klamath River channel cross section at river mile 106 near Happy Camp (Asarian and Kann 2013). Cross section from data in Ayres Associates (1999) for site number 3, cross section number 5.

High levels of photosynthesis cause dissolved oxygen concentration to rise during the day and lower at night during plant respiration. Low dissolved oxygen concentration at night reduces rearing habitat suitability at night. Daily fluctuations of up to 2 mg/L of dissolved oxygen in the mainstem Klamath River downstream from IGD have been attributed to daytime algal photosynthesis and nocturnal algal/bacterial respiration (Karuk Tribe of California 2002, 2003; YTEP 2005, NCRWQCB 2010).

In addition, the overall effect of the conceptual linkages between flow and dissolved oxygen is supported by an analysis of 11 years of mainstem Klamath River water quality data that found that higher flows were strongly correlated with higher dissolved oxygen minimums and narrower daily dissolved oxygen range (Figure 11.21, Asarian and Kann 2013). Therefore, when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD and Orleans (RM 59). The proposed action's contribution to dissolved oxygen reduction likely diminishes around Orleans (RM 59) as tributary accretions offset the dissolved oxygen reductions near this site.

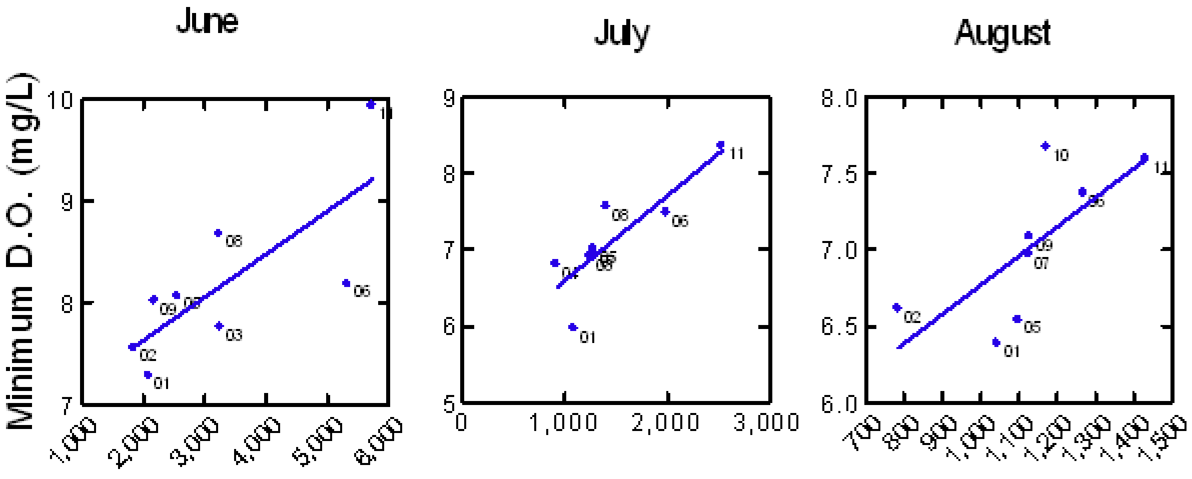


Figure 11.21. Monthly mean of daily minimum dissolved oxygen concentration vs. monthly average flow, by month for mainstem Klamath River at Seiad Valley 2001-2011. Spearman's rho values are: 0.79 for June (p=0.021), 0.952 for July (p<0.001), 0.857 for August (p=0.007). Points are labeled with 2-digit year (Asarian and Kann 2013).

While the exact amount and extent of the proposed action's water quality effects are unknown, the proposed action's contribution to impaired water quality conditions adversely affects the rearing habitat element of coho salmon critical habitat. As discussed in the *Environmental Baseline*, dissolved oxygen concentrations regularly fall below 8 mg/L in the mainstem Klamath River during the summer (Karuk Tribe of California 2001, 2002, 2007, 2009, 2010, 2011), which is the minimum concentration for suitable salmonid rearing (USEPA 1986). Therefore, the proposed action will likely contribute to adverse effects to the rearing habitat element of coho salmon critical habitat when dissolved oxygen concentrations fall below 8 mg/L in the mainstem Klamath River during the summer.

11.4.1.2.3.4 Ramp-Down Rates

NMFS expects the proposed ramp-down rates when flows at IGD are greater than 3,000 cfs will generally reflect natural flow variation. When flows are higher than 3,000 cfs, NMFS expects habitat effects, such as disconnection of off-channel habitats from the mainstem Klamath River as flows recede, to be representative of natural hydrologic conditions. NMFS previously determined that the proposed ramp-down rates below 3,000 cfs minimize adverse effects to essential features of coho salmon habitat (e.g., rearing, spawning habitat features; NMFS 2002, 2010). The decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period when IGD flows are 1,750 cfs or less are not likely to adversely affect juvenile coho salmon critical habitat.

11.4.2 Restoration Activities

Reclamation has proposed to fund conservation measures to improve conditions for coho salmon. Restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1. The specific timing and duration of each individual restoration project will vary depending on the project type, specific project methods, and site conditions. However, the duration and magnitude of short-term effects to coho salmon critical habitat associated with implementation of individual restoration projects will be minimized due to the multiple proposed avoidance and minimization measures.

Implementing individual restoration projects during the summer low-flow period will significantly minimize exposure to emigrating coho salmon smolts and coho salmon adults at all habitat restoration project sites. The total number and location of restoration projects funded annually will vary from year to year depending on various factors, including project costs, funding and scheduling. Assuming the number of restoration activities is similar to PacifiCorp's $500,000 coho enhancement fund (PacifiCorp 2013), Reclamation's $500,000 restoration fund will likely result in four to six restoration projects being implemented each year.

Except for riparian habitat restoration and streamflow augmentation, all proposed restoration types may result in short-term adverse and long-term beneficial effects to coho salmon critical habitat. Despite the different scope, size, intensity, and location of these proposed restoration actions, the potential short-term adverse effects to coho salmon all result from dewatering and increased sediment. The effects from increased sediment mobilization into streams are usually indirect effects to critical habitat because they are reasonably certain to occur and are later in time.

11.4.2.1 Not Likely to Adversely Affect

Of the proposed restoration project types, several are expected to have only beneficial effects to coho salmon critical habitat. Some of the water conservation projects occur beyond a diversion point (barrier to fish); therefore, the projects are not likely to adversely affect fish or their habitat and provide benefits by increasing instream water availability. Riparian habitat restoration actions occur outside of the wetted channel, and likely have only wholly beneficial effects to coho salmon and their habitat. Water conservation projects, such as water storage tanks and piping ditches, can restore rearing and spawning habitats, as well as improves access to these habitats when stream flows are diverted less as a result of the water delivery efficiencies. The specific effects of these restoration types are discussed below.

1. <u>Riparian Habitat Restoration</u>

Riparian habitat restoration techniques as outlined in the CDFW's California Salmonid Stream Habitat Restoration Manual (Restoration Manual; Flosi et al. 2010) are not likely to adversely affect listed salmonids or their habitat. All vegetation planting or removal (in the case of exotic species) will likely occur on stream banks and floodplains adjacent to the wetted channel and not in flowing water. Since the majority of work will occur during the summer growing season (a few container plants require winter planting), riparian plantings should be sufficiently established prior to the following winter storm season. Thus, project-related erosion following the initial planting season is unlikely since established plants will help anchor the restoration worksite. The long-term benefit from riparian restoration will be the establishment of a vibrant, functional riparian corridor providing juvenile and adult fish with abundant food and cover. By restoring degraded riparian systems, listed salmonids will be more likely to survive and recover in the future.

Riparian restoration projects will increase stream shading and instream cover habitat for rearing juveniles, moderate stream temperatures, and improve water quality through pollutant filtering. Beneficial effects of constructing livestock exclusionary fencing in or near streams include the rapid regrowth of grasses, shrubs, and other vegetation released from overgrazing, and reduced nitrogen, phosphorous, and sediment loading into the stream environment (Line et al. 2000; Brenner and Brenner 1998). Further, Owens et al. (1996) found that stream fencing has proven to be an effective means of maintaining appropriate levels of sediment in the streambed. Another documented, beneficial, long-term effect is the reduction in bankfull width of the active channel and the subsequent increase in pool area in streams (Magilligan and McDowell 1997). All will contribute to a more properly functioning ecosystem for listed species by providing additional spawning and cover habitat relative to their current condition.

2. <u>Water Conservation</u>

Implementing water conservation measures will wholly benefit coho salmon by returning some flow to the stream at a time when coho salmon require adequate habitat to rear and migrate. Increasing instream flow levels by diminishing water diversions will provide juvenile coho salmon with better access to suitable rearing and spawning habitat, especially during the summer and early fall when flows are lowest. Water conservation projects are most likely to occur in the tributaries, such as the Shasta and Scott rivers. Therefore, short-term restoration of flows are expected to affect only the tributaries because the next priority water right user or riparian water right user is likely to divert those flows and water conserved at the restoration site is likely to increase instream flows in a relatively small reach of these tributaries.

Installing water measuring devices will likely result in discountable or insignificant effects to listed species because these activities typically occur in diversion ditches where increased mobilization of sediment is unlikely to reach the stream channel. Construction of tail water ponds will improve water quality by minimizing the return of warm, nutrient rich water into the river.

Therefore, the following components of the proposed restoration actions are expected to result in insignificant, discountable, or wholly beneficial effects to coho salmon and their designated critical habitat relative to existing conditions: riparian habitat restoration, development of alternative stockwater supply, tailwater collection ponds, water storage tanks, and piping ditches. Some components of the restoration activities also may result in effects, such as temporary instream habitat disturbance from heavy equipment operation, riparian vegetation disturbance, chemical contamination, and reduced benthic macroinvertebrate production that are not likely to adversely affect listed species or their critical habitats. These effects are expected to be insignificant or discountable as explained further below.

11.4.2.1.1 Spawning Habitat

Spawning habitat is not likely to be adversely affected by the temporary increase in fine sediment resulting from the proposed restoration activities. Spawning habitat is located where water velocities are higher, where mobilized fine sediment is less likely to settle. Where limited settling does occur in spawning habitat, the minimally increased sediment is not expected to degrade spawning habitat due to the small amounts and short-term nature of the effects. Restoration activities will improve the quality of spawning habitat over the long term. Spawning habitat will be improved by reducing the amount of suspended sediment that enters the stream in the long term through various types of erosion control. Additionally, gravel augmentation, described in the proposed action will increase the amount of spawning habitat available.

NMFS expects projects that restore access to spawning habitat will increase the conservation value of existing critical habitat, particularly in the mainstem Klamath River downstream of IGD. Increasing available spawning habitat will allow for recolonization of new habitats by returning adults, increasing spatial structure and productivity. Projects that open up previously blocked habitat are expected to increase the range of available spawning habitat for the conservation of coho salmon, and are not expected to adversely affect coho salmon critical habitat.

The augmentation of gravel in the river downstream from IGD and possibly in tributaries of the Klamath River will partially restore spawning habitat for coho salmon. In the Sacramento-San Joaquin River system, gravel augmentation is a common practice, and researchers there have observed increased spawner use of the new gravel supplied by gravel augmentation (Merz and Chan 2005, Cummins et al. 2008). Properly functioning spawning substrate provides ample interstitial flow through redds, and is of suitable size to permit efficient redd excavation by spawning adults. Effective salmon spawning has been observed downstream of other dams, where suitable substrate has been present (Swan 1989, Giorgi 1992, Geist and Dauble 1998). NMFS expects the same potential to be realized on the mainstem Klamath River between IGD (RM 190) and Shasta River (RM 176) and in the tributaries. Overall, NMFS expects that gravel augmentation will improve the function and conservation value of critical habitat for adult spawning below IGD and potentially in tributaries

11.4.2.1.2 Adult and Juvenile Migration Habitat

Migratory habitat is essential for juvenile salmonids outmigrating to the ocean as well as adults returning to their natal spawning grounds. Migratory habitat may be affected during the temporary re-routing of the channel during project implementation; however, a migratory corridor will be maintained at all times. The proposed action will have long term beneficial effects to migratory habitat. Activities adding complexity to habitat will increase the number of pools, providing resting areas for adults, and the removal of barriers will increase access to habitat. Therefore, NMFS expects restoration projects that restore access to habitat will increase the conservation value of existing critical habitat.

11.4.2.1.3 Rearing Habitat

Most proposed fisheries restoration actions are expected to avoid disturbing riparian vegetation through the proposed avoidance and minimization measures. However, there may be limited situations where avoidance is not possible. In the event that streamside riparian vegetation is removed, the loss of riparian vegetation is expected to be small, due to minimization measures, and limited to mostly shrubs and an occasional tree. Most riparian vegetation impacts are expected to be typical riparian species such as willows and other shrubs, which are generally easier to recover or reestablish. In addition, the revegetation of disturbed riparian areas is expected to further minimize the loss of vegetation. Therefore, NMFS anticipates only an insignificant loss of riparian habitat and function within the action area to result from the proposed restoration activities.

Equipment refueling, fluid leakage, and maintenance activities within and near the stream channel pose some risk of contamination and potential take. In addition to toxic chemicals associated with construction equipment, water that comes into contact with wet cement during construction of a restoration project can also adversely affect water quality and may harm listed salmonids. However, all fisheries restoration projects will include the measures outlined in the sections entitled, *Measures to Minimize Disturbance From Instream Construction* and *Measures to Minimize Degradation of Water Quality* within Part IX of the Restoration Manual (Flosi et al. 2010), which address and minimize pollution risk from equipment operation. Therefore, water quality degradation from toxic chemicals associated with the habitat restoration projects is discountable.

Benthic (i.e., bottom dwelling) aquatic macroinvertebrates may be temporarily lost or their abundance reduced when stream habitat is dewatered (Cushman 1985). Effects to aquatic macroinvertebrates resulting from stream flow diversions and dewatering will be temporary because instream construction activities will occur only during the low flow season, and rapid recolonization (about one to two months) of disturbed areas by macroinvertebrates is expected following rewatering (Cushman 1985, Thomas 1985, Harvey 1986). In addition, the effect of macroinvertebrate loss on juvenile coho salmon is likely to be negligible because food from upstream sources (via drift) would be available downstream of the dewatered areas since stream flows will be maintained around the project work site. Based on the foregoing, the loss of aquatic macroinvertebrates resulting from dewatering activities is not likely to adversely affect coho salmon.

11.4.2.2 Likely to Adversely Affect

Misguided restoration sometimes fails to produce the intended benefits and can even result in reduced species fitness (Jeffreys and Moyle 2012) or further habitat degradation. Improperly constructed projects typically cause greater adverse effects than the pre-existing condition. The most common reason for this is improper identification of the design flow for the existing channel conditions.

Typically, in-stream work with heavy equipment for habitat restoration takes place during the lowest flows of the year (summer/early fall). Working in this time period is most preferred in order to minimize disturbances to active channel beds, minimize the production of sediment, minimize disturbance of aquatic invertebrates, and allow enough time to revegetate disturbed soils. In-water work may require disturbing existing rearing habitat structure(s) in order to remove a passage barrier or place habitat structures (e.g., large wood or gravel). However, those effects are expected to be localized and negligible in terms of adverse effects to the conservation value of habitat. Temporary effects to critical habitat may include disturbance of the channel bed resulting in localized sediment plumes, or diversion of surface waters if necessary to isolate a permanent barrier removal worksite. Such diversions would likely be of relatively short duration with reconnection of the worksite upon completion of the restoration.

NMFS anticipates adverse effects to critical habitat from habitat restoration actions to be minor and short-term as most projects are anticipated to occur as one time disturbance events within the summer period when flows are lowest. Short-term adverse effects to rearing habitat will primarily occur as a result of dewatering the channel and increasing sediment input during instream activities. Loss of rearing sites can occur through dewatering habitat and the filling of pools with fine sediment. However, these adverse effects are expected to be temporary, and any minor disturbance to the restoration site is likely to recover within one additional year (e.g., revegetation of disturbed soils or elimination of turbid flows).

11.4.2.3 Beneficial Effects to Coho Salmon Critical Habitat

Reclamation proposes to support restoration actions for the purpose of improving the conservation value of coho salmon critical habitat. Habitat restoration projects that are funded by Reclamation will be designed and implemented consistent with the techniques and minimization measures presented in the CDFW's Restoration Manual (Flosi et al. 2010) to maximize the benefits of each project while minimizing effects to salmonids. Most restoration projects are for the purpose of restoring degraded salmonid habitat and are intended to improve instream cover, pool habitat, spawning gravels, and flow levels; remove barriers to fish passage; and reduce or eliminate erosion and sedimentation impacts. Others prevent fish injury or death, such as diversion screening projects. Although some habitat restoration projects may fail or cause small losses to the juvenile coho salmon in the project areas during construction, most of these projects are anticipated to restore salmonid habitat over the long-term.

The CDFW Restoration Manual (Flosi et al. 2010) provides design guidance and construction techniques that facilitate proper design and construction of restoration projects. Properly constructed stream restoration projects will increase access, habitat complexity, stability of channels and streambanks, spawning habitat quality, and instream shade and cover. Since 2004, the annual percentage of implemented and monitored project features[7] in northern California that were rated as either good or excellent ranged between 58.5 to 85 percent, with an average of 70.9 percent (Collins 2005; CDFG 2006-2012, CDFW 2013). NMFS assumes restoration projects implemented under the proposed action will have similar effectiveness rates during the next 10 years because the Fisheries Restoration Grant Program project features evaluated are the same type of restoration as under this proposed action. Therefore, the proposed restoration should amount to about 71 percent effectiveness each year.

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[7] The Fisheries Restoration Grant Program project features evaluated are the same types of restoration as under this proposed action

Table 11.13. Annual percent of project effectiveness of California Department of Fish and Wildlife's Fisheries Restoration Grant Program in Northern California (Collins 2005; CDFG 2006-2012, CDFW 2013).

Year	Projects Features with Good or Excellent Rating*	Total Project Features Evaluated*	Percent of total
2004	19	27	70.4
2005	402	473	85.0
2006	59	87	67.8
2007	20	27	74.1
2008	55	77	65.5
2009	62	106	58.5
2010	38	56	67.9
2011	41	55	74.5
2012	20	27	74.1
Total annual average			70.9
*excludes upslope watershed projects			

a. Instream Habitat Improvements

Instream habitat structures and improvement projects will provide cover for juveniles to escape predators and rest, increase spawning habitat, improve upstream and downstream migration corridors, improve pool to riffle ratios, and add habitat complexity and diversity. Some structures will be designed to reduce sedimentation, protect unstable banks, stabilize existing slides, provide shade, and create scour pools. Stream enhancement techniques aimed at reducing juvenile displacement downstream during winter floods and at providing deep pools during summer low flows could substantially increase stream rearing capacity for coho salmon (Narver 1978).

Placement of LWD into streams can result in the creation of pools that influence the distribution and abundance of juvenile salmonids (Spalding et al. 1995, Beechie and Sibley 1997). LWD influences the channel form, retention of organic matter and biological community composition. In small (<10 m bankfull width) and intermediate (10-20 m bankfull width) streams, LWD contributes channel stabilization, energy dissipation and sediment storage (Cederholm et al. 1997). Presence and abundance of LWD is correlated with growth, abundance and survival of juvenile salmonids (Fausch and Northcote 1992, Spalding et al. 1995). The size of LWD is important for habitat creation (Fausch and Northcote 1992).

For placement of root wads, digger logs, upsurge weirs, boulder weirs, vortex boulder weirs, boulder clusters, and boulder wing-deflectors (single and opposing), long-term beneficial effects are expected to result from the creation of scour pools that will provide rearing habitat for juvenile coho salmon. Improper use of weir and wing-deflector structures can cause accelerated erosion on the opposing bank; however, this can be avoided with proper design considerations. Proper placement of single and opposing log wing-deflectors and divide logs will provide long-term beneficial effects from the creation or enhancement of pools for summer rearing habitat and cover for adult salmonids during spawning. Proper placement of digger logs will likely create scour pools that will provide complex rearing habitat, with overhead cover, for juvenile salmonids and low velocity resting areas for migrating adult salmonids. Spawning gravel augmentation will provide long-term beneficial effects by increasing spawning gravel availability while reducing inter-gravel fine sediment concentrations.

In addition, where there is stream bank erosion, the installation of various weir structures and wing-deflector structures will direct flow away from unstable banks and provide armor (a hard point) to protect the toe of the slope from further erosion. Boulder faces in the deflector structures have the added benefit of providing invertebrate habitat, and space between boulders provides juvenile salmonid escape cover.

b. Instream Barrier Modification for Fish Passage Improvement

Instream barrier modification for fish passage improvement projects will improve salmonid fish passage and increase access to suitable salmonid habitat. Long-term beneficial effects are expected to result from these projects by improving passage at sites that are partial barriers, and by providing passage at sites that are total barriers. Manual modifications to tributary mouths may restore access for juvenile coho salmon between the mainstem and the tributaries. All of these restoration projects will provide better fish passage.

c. Stream Bank Stabilization

Stream bank stabilization projects will reduce sedimentation from watershed and bank erosion, decrease turbidity levels, and improve water quality for coho salmon over the long-term. Reducing sediment delivery to the stream environment will improve fish habitat and fish survival by increasing fish embryo and alevin survival in spawning gravels, reducing injury to juvenile salmonids from high concentrations of suspended sediment, and minimizing the loss of quality and quantity of pools from excessive sediment deposition. Successful implementation of stream bank stabilization projects will offset the increased sediment delivery into streams from other activities. In addition, streambank restoration activities will likely restore native riparian forests or communities, provide increased cover (large wood, boulders, vegetation, and bank protection structures) and a long-term source of all sizes of instream wood. Since no riprap or gabions are including in the proposed stream bank stabilization, the effects of the stream bank stabilization are expected result in long term benefits to coho salmon critical habitat in the action area.

d. Fish Passage Improvement at Stream Crossings

Thousands of dilapidated stream crossings exist on roadways throughout the coastal drainages of northern and central California, many preventing listed salmonids from accessing vast expanses of historic spawning and rearing habitat located upstream of the structure. In recent years, much attention has been focused on analyzing fish passage at stream crossings through understanding the relationship between culvert hydraulics and fish behavior (Six Rivers National Forest Watershed Interaction Team 1999). Most juvenile coho salmon spend approximately one year in freshwater before migrating to the ocean. Thus, juvenile coho salmon are highly dependent on stream habitat.

Juvenile salmonids often migrate relatively long distances (i.e., several kilometers) in response to: 1) changes in their environment (e.g., summer warming or pollution events), 2) changes in resource needs as they grow, and 3) competition with other individuals. The movements of stream-dwelling salmonids have been the subject of extensive research (Chapman 1962, Edmundson et al. 1968, Fausch and White 1986, Gowan et al. 1994, Bell 2001, Kahler et al. 2001). Although many juvenile salmonids are territorial or exhibit limited movement, many undergo extensive migrations (Gowan et al. 1994, Fausch and Young 1995). For example, salmonid fry often disperse downstream from headwater spawning sites. Additional movements can occur as intraspecific competition for resources causes the additional dispersal of subordinate individuals (Chapman 1966, Everest and Chapman 1972, Hearn 1987). Juvenile salmonids are likely to move in response to growth or simply because environmental conditions such as water depth or velocity are no longer suitable (Edmundson et al. 1968, Leider et al. 1986, Lau 1994, Kahler et al. 2001).

e. Fish Screens

Water diversions can greatly affect aquatic life when organisms are entrained into intake canals or pipes -- an estimated 10 million juvenile salmonids were lost annually through unscreened diversions in the Sacramento River alone (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council 1989). Once entrained, juvenile fish can be transported to less favorable habitat (e.g., a reservoir, lake or drainage ditch) or killed instantly by turbines. Fish screens are commonly used to prevent entrainment of juvenile fish in water diverted for agriculture, power generation, or domestic use.

Fish screens substantially decrease juvenile fish loss in stream reaches where surface flow is regularly diverted out of channel. Surface diversions vary widely in size and purpose, from small gravity fed diversion canals supplying agricultural water to large hydraulic pumping systems common to municipal water or power production. All screening projects have similar goals, most notably preventing fish entrainment into intake canals and impingement against the mesh screen. To accomplish this, all screening projects will follow CDFW and NMFS guidelines, which outline screen design, construction and placement, as well as designing and implementing successful juvenile bypass systems that return screened fish back to the stream channel.

Fish screen projects will reduce the risk for fish being entrained into irrigation systems. Well-designed fish screens and associated diversions ensure that fish injury or stranding is avoided, and fish are able to migrate through stream systems at the normal time of year.

11.4.2.4 Summary

Although Reclamation’s funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects the suite of restoration activities will result in longer term improvements to the function and role of critical habitat in the action area. Based on information on the PacifiCorp’s coho enhancement fund (PacifiCorp 2013), NMFS estimates approximately four to six restoration projects will be implemented each year throughout the mainstem Klamath River and major tributaries. Approximately 71 percent of the four to six restoration projects each year will be successful at increasing the conservation value for coho salmon fry and juveniles.

Because of inflation, as the cost of restoration increases, the proposed $500,000 annual restoration fund will be able to fund fewer restoration projects in the latter half of the proposed action duration. The average annual rate of inflation in California over the past 10 years (i.e., 2003 to 2012) is 2.6 percent (CA Department of Finance 2013). However, NMFS also notes that the ecological needs of coho salmon will likely continue to be better understood over the 10 year action period, and that restoration activities are likely to become more effective at benefiting coho salmon habitat throughout that period. Therefore, the increased understanding of coho salmon and habitat restoration is likely to approximately offset the effects of inflation with the result that the restoration benefits to coho salmon are likely to be reasonably similar over the 10 year proposed action period.

11.5 Cumulative Effects

Cumulative effects are those impacts of future State, Tribal, and private actions that are reasonably certain to occur within the area of the action subject to consultation. Tribal lands are excluded from the designation of critical habitat for the SONCC coho salmon ESU. Therefore, for purposes of the analysis of effects on critical habitat, there are no Tribal actions that are reasonably certain to occur within the area of the action subject to consultation. Future Federal actions will be subject to the consultation requirements established in Section 7 of the Act, and therefore are not considered cumulative to the proposed action.

NMFS believes that SONCC coho salmon ESU critical habitat may be affected by numerous future actions by State, local, or private entities that are reasonably certain to occur in, adjacent, or upslope of the action area, as described below and in the *Environmental Baseline* section. Many activities described in the *Environmental Baseline* section are reasonably certain to continue in the future even though NMFS lacks definitive information on the extent or location of many of these categories of actions. The effects of those future non-Federal actions on SONCC coho salmon ESU critical habitat are likely to be similar to those discussed in the *Environmental Baseline*.

11.5.1 Control of Wildland Fires on Non-Federal Lands

Control of wildland fires may include the removal or modification of vegetation due to the construction of firebreaks or setting of backfires to control the spread of fire. This removal of vegetation can trigger post-fire landslides as well as chronic sediment erosion that can negatively affect downstream coho salmon habitat. Also, the use of fire retardants may adversely affect salmonid habitat if used in a manner that does not sufficiently protect streams causing the potential for coho salmon to be exposed to lethal amounts of the retardant. This exposure is most likely to affect summer rearing juvenile coho salmon. As wildfires are unpredictable events, NMFS cannot determine the extent to which suitable coho salmon habitat may be degraded or modified by these activities.

11.5.2 Klamath River Basin Adjudication

Based on the Oregon Water Resources Department's Findings of Fact and Order of Determination in the Klamath River Basin Adjudication, the United States holds senior water rights on behalf of the Klamath Tribes in certain reaches of major tributaries to the UKL. If the United States makes calls on behalf of the Klamath Tribes for regulation of junior waters users in these tributaries, the Oregon Water Resources Department's regulation of junior water users could result in higher inflows into UKL, and thus could increase flows in the mainstem Klamath River for coho salmon. However, as discussed in the *Background and Consultation History* section, the potential effects of the Findings of Fact and Order of Determination are still uncertain and will likely remain uncertain for several years.

11.5.3 Residential Development and Existing Residential Infrastructure

Human population growth in the action is expected to remain relatively stable over the next 10 years as California's economy continues to recover from a long-lasting nationwide recession. The recession has had significant economic impacts at both the statewide and local scales with widespread impacts to residential development and resource industries such as timber and fisheries. However, some development will continue to occur which, on a small-scale, can impact coho salmon habitat. Once development and associated infrastructure (e.g., roads, drainage, and water development) are established, the impacts to aquatic species are expected to be permanent. Anticipated impacts to aquatic resources include loss of riparian vegetation, changes to channel morphology and dynamics, altered hydrologic regimes (increased storm runoff), increased sediment loading, and elevated water temperatures where shade-providing canopy is removed. The presence of structures and/or roads near waters may lead to the removal of large woody debris in order to protect those structures from flood impacts. The anticipated impacts to Pacific salmonids from continued residential development are expected to be sustained and locally intense. Commonly, there are also effects of home pesticide use and roadway runoff of automobile pollutants, introductions of invasive species to nearby streams and ponds, attraction of salmonid predators due to human occupation (e.g., raccoons), increased incidences of poaching, and loss of riparian habitat due to land clearing activities. All of these factors associated with residential development can have negative impacts on salmon populations.

A subset of this development may occur for the purposes of marijuana cultivation. Watersheds associated with the action area have been used to produce marijuana crops both legally and illegally. California law allows for the production of marijuana for medicinal purposes under Proposition 215 which establishes limits to the production of marijuana by patients or their designated growers. NMFS does not expect that cultivation of marijuana under Proposition 215 limits will result in adverse effects to coho salmon habitat because these cultivations are relatively small. However, illegal marijuana production within watersheds of the action area can at times result in grow operations of over 100,000 plants; often these illegal grows occur on federal lands. NMFS expects these illegal grow operations to continue on isolated parcels in the watersheds adjacent to the action area. These grow operations can adversely affect coho salmon habitat by diversion of water for irrigation, resulting in the drying of streams or draining of pools that provide rearing habitat for coho salmon juveniles. The operations can also contaminate nearby streams by the discharge of pesticides, rodenticides, and fertilizers to nearby streams. Such influx of contaminants can be lethal to exposed coho salmon, or result in the alteration of stream habitats via eutrophication.

11.5.4 Recreation, Including Hiking, Camping, Fishing, and Hunting

Expected recreation impacts to salmonids include increased turbidity, impacts to water quality, barriers to movement, and changes to habitat structures. Streambanks, riparian vegetation, and spawning redds can be disturbed wherever human use is concentrated. Campgrounds can impair water quality by elevating nutrients in streams. Construction of summer dams to create swimming holes causes turbidity, destroys and degrades habitat, and blocks migration of juveniles between summer habitats. Impacts to salmonid habitat are expected to be localized, mild to moderate, and temporary. Fishing within the action area, typically for steelhead or Chinook salmon, is expected to continue subject to CDFW regulations. Fishing for coho salmon directly is prohibited in the Klamath River. The level of impact to coho salmon within the action area from angling is unknown, but is expected to remain at current levels.

11.5.5 Total Maximum Daily Loads

The Oregon Department of Environmental Quality completed a TMDL analysis and report in 2002 for the Upper Klamath and Lost River subbasins within the Klamath Basin. In 2010, the California State Water Resources Control Board adopted TMDLs to address temperature, dissolved oxygen, nutrients, and microcystin impairments in the Klamath. Modeling performed during the Klamath TMDL process indicates that water temperatures in the Klamath basin would improve following full implementation of the TMDL programs with corresponding actions taken by landowners and land managers to reduce elevated water temperatures (NCRWQCB 2010). Actual improvements to water temperature and other water quality impairments in the Klamath River basin will depend on the States of Oregon and California's successful implementation and enforcement of most if not all of the Klamath River basin TMDLs.

11.6 Integration and Synthesis

The integration and synthesis is the final step of NMFS' assessment of the risk posed to critical habitat as a result of implementing the proposed action. In this section, NMFS adds the effects of the action to the environmental baseline and the cumulative effects to formulate NMFS' biological opinion on whether the proposed action is likely to appreciably diminish the value of designated critical habitat for the conservation of the species. This assessment is made in full consideration of the status of SONCC coho salmon ESU critical habitat.

In designating critical habitat for the SONCC coho salmon ESU, NMFS identified the following five essential habitat types: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Within these areas, essential features of coho salmon critical habitat include adequate: (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (64 FR 24049; May 5, 1999). The mainstem rearing life-history strategy common to coho salmon within the Klamath River occurs not just in summer and winter, but in fact year-round. Accordingly, NMFS will consider Project effects to juvenile rearing habitat throughout the year, where applicable.

When evaluating critical habitat within the action area, the analysis of Project effects will be restricted to the Upper and Middle Klamath River reaches (i.e., between IGD and Trinity River), while the analysis of restoration activities will include the Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon River. Critical habitat within the mainstem action area is not currently designated below the Trinity River (tribal land) or above Iron Gate Dam (impassable barrier).

11.6.1 Condition of Critical Habitat at the ESU Scale

Section 11.2 of this BiOp, *Status of SONCC Coho Salmon Critical Habitat*, details the condition of critical habitat at the ESU scale. In summary, the current condition of critical habitat of the SONCC coho salmon ESU is mostly degraded. Although there are exceptions, the majority of streams and rivers in the ESU have impaired habitat. Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing and past human activities. For example, large dams, such as the William L. Jess Dam on the Rogue River in Oregon, stop the recruitment of spawning gravels and large wood, which impacts both essential habitat types (spawning and rearing areas) as well as an essential feature of spawning areas (substrate). Water use in many regions throughout the ESU reduces summer base flows, which limits the establishment of several essential features such as water quality and water quantity. Meanwhile, habitat restoration throughout the range of the SONCC coho salmon ESU has been improving the conservation value of critical habitat for coho salmon.

11.6.2 Condition of Critical Habitat in the Interior Klamath Diversity Stratum

The current condition of critical habitat in the Interior-Klamath diversity stratum, which includes the Upper and Middle Klamath River reaches, is degraded. Sedimentation, low summer flows, poor water quality, stream habitat simplification, and habitat loss from poorly designed road crossings and diversion structures continue to impair coho salmon streams in this stratum. Past and ongoing human activities often preclude sufficient recovery of critical habitat in the Interior Klamath diversity stratum to establish essential features. Water use in many regions throughout the diversity stratum (e.g., Shasta and Scott rivers) reduces summer base flows, which, in turn, limit the re-establishment of the essential features of water quantity and water quality. Since the early 1990s, habitat restoration efforts in much of the Interior-Klamath diversity stratum have been incrementally improving the conservation value of critical habitat in the action area. This is evidenced by significant strides in the implementation of livestock exclusion riparian fencing, riparian planting, thermal refugia protection/enhancement, wetland habitat enhancement, fish exclusion screening, water use efficiency, and agricultural water leasing programs. The aggregate benefits from these habitat restoration efforts will be integral to the recovery of SONCC coho salmon in the Interior-Klamath diversity stratum.

11.6.3 Project Effects on Essential Habitat Types

Critical habitat for SONCC coho salmon ESU is comprised of physical and biological features that are essential for the conservation of coho salmon, including spawning habitat, rearing habitat, and migration corridors to support one or more life stages of SONCC coho salmon. As summarized below, the conservation value of critical habitat in certain reaches of the Klamath River between IGD and approximately Orleans is likely to be reduced by Project operations at certain times or under certain environmental conditions. However, restoration activities under the proposed action are likely to offset those reductions or enhance, in some cases, the conservation value of critical habitat in the action area.

11.6.3.1 Spawning Habitat

The proposed action will reduce the magnitude, frequency, and duration of flows between 5,000 and 10,000 cfs relative to the natural flow regime, which will likely reduce mobilization of fines from spawning gravel. Therefore, the proposed action is likely to reduce some quality of spawning habitat when spawning gravel becomes filled by fines over time. While the proposed action will likely reduce the duration, magnitude and frequency of fine sediment mobilization from spawning gravel when IGD flows are below 10,000 cfs, adult coho salmon are able to clean fine sediment from spawning gravel (Kondolf et al. 1993, Kondolf 2012) prior to depositing eggs. In addition, the proposed action is not likely to result in armoring of spawning gravel because the proposed action will have minimal reductions to the magnitude, frequency, and duration of flows needed to mobilize armored substrates (i.e., at least approximately 10,000 cfs; Reclamation 2011b) relative to the natural hydrograph. During relatively wet years when IGD flows are variable and incrementally increase during the late fall and winter, the proposed action is expected to increase the quantity of spawning habitat in the mainstem Klamath River. Therefore, NMFS expects that the quantity of coho salmon spawning habitat will be suitable under the proposed action.

Spawning habitat is not likely to be adversely affected by the temporary increase in fine sediment resulting from the proposed restoration activities. Restoration activities will improve the quality of spawning habitat over the long term by reducing the amount of suspended sediment that enters the stream through various types of erosion control. Additionally, gravel augmentation will increase the amount of spawning habitat available.

In summary, the proposed action is likely to have minimal adverse effects to spawning habitat quality in the mainstem Klamath River during consecutive dry water years. However, the proposed action is likely to result in improvements to spawning habitat quality in the action area through gravel augmentation, and sediment reduction projects.

11.6.3.2 Migratory Corridors

The proposed action is not likely to adversely affect the migratory corridor for coho salmon in the action area. The proposed action will lower flows in the mainstem Klamath River during much of November and December. However, the November and December flows of at least 950 cfs under the proposed action will provide the depth and velocity for coho salmon migration, and thus, are not expected to impede adult migration. In addition, the proposed action retains some aspects of a natural flow regime through flow variability, which will provide adult coho salmon migration cues commensurate with natural hydrologic conditions. The juvenile migration corridor within the mainstem Klamath River is also expected to be suitable at flows of at least 900 cfs. Navigating shallow channel sections is easier for juvenile coho salmon than adult salmon due to their smaller size. Lastly, given the minimal reduction to stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries.

Restoration activities funded under the proposed action may result in short-term disturbance to migration corridors for coho salmon when stream channels need to be temporarily re-routed; however, a migratory corridor will be maintained at all times. Activities adding complexity to habitat will increase the number of pools, providing resting areas for adults, and the removal of barriers will increase access to habitat. NMFS expects restoration projects that restore access to rearing and spawning habitat will increase the conservation value of existing critical habitat in the action area. Increasing available spawning habitat will allow for recolonization of new habitats by returning adults, increasing spatial structure and productivity. Restoration projects that open up previously blocked habitat are expected to increase the range of available rearing and spawning habitat for the conservation of coho salmon, and are not expected to adversely affect coho salmon critical habitat. Therefore, NMFS expects restoration projects that restore complexity to migratory corridors and access to habitats will increase the conservation value of existing critical habitat.

In summary, the proposed action is not likely to adversely affect migratory corridors for coho salmon in the action area, and is likely to result in long term beneficial effects to migratory corridors from the proposed restoration activities.

11.6.3.3 Rearing Habitat

11.6.3.3.1.1 Habitat Availability

The proposed action will reduce coho salmon fry habitat availability in the mainstem Klamath River between IGD (RM 190) to the Salmon River (RM 65.5) in below average years (≥ 60 percent exceedance), and in wet years (≥ 15 percent exceedance; Table 11.9) in June. While the actual extent of habitat reduction is not known, the habitat reduction is greatest in the IGD to Scott River reaches because the relationship between flow and percent of maximum habitat is steepest in these reaches (Figure 11.17). In addition, the proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River between the Trees of Heaven (RM 172) to Rogers Creek (RM 72) reaches at various times of the year and at various water exceedances (Tables 11.10 to 11.12). Of the three reaches, the proposed action reduces coho salmon juvenile habitat availability in the Rogers Creek reach in most water years and in all months between October and June (Table 11.12). The effects of flow reduction on juvenile coho salmon habitat availability in the mainstem Klamath River vary spatially and temporally downstream of IGD

While there will be reductions in rearing habitat availability, the proposed action does provide flow variability in the mainstem Klamath River. Flow variability will occur during precipitation and snowmelt events, reflecting qualities of a natural flow regime. When hydrologic conditions in the upper Klamath Basin are wet, flow variability under the proposed action will result in higher flows in the mainstem Klamath River downstream of IGD. Temporary increases in mainstem flows are expected to result in short-term increases in the amount and quality of habitat in the mainstem for fry and juvenile coho salmon. Therefore, the adverse effects to coho salmon fry habitat in the mainstem Klamath River between IGD and the Salmon River are likely to be somewhat moderated by the flow variability under the proposed action when hydrological conditions in the upper Klamath Basin are wet. During dry hydrologic conditions in the Klamath Basin, the proposed action will minimize adverse effects to coho salmon fry in April to June by not reducing flows in the mainstem Klamath River below what Hardy et al. (2006) considers to be acceptable levels of risk to the health of aquatic resources.

NMFS anticipates adverse effects to critical habitat from habitat restoration to be minor and short-term as most restoration projects are anticipated to occur as one time disturbance events within the summer period when flows are lowest. Short-term adverse effects to rearing habitat will primarily occur as a result of dewatering the channel and increasing sediment input during instream activities. Temporary reduction of rearing habitat can occur through dewatering habitat and the filling of pools with fine sediment.

Despite the minor and short-term adverse effects, NMFS expects the suite of restoration activities will result in long term improvements to the function and role of rearing habitat in the action area. Approximately 71 percent of the four to six restoration projects implemented each year will be successful at increasing the conservation value of coho salmon rearing habitat. For example, instream habitat structures and improvement projects will provide cover for juveniles to escape predators and rest, improve pool to riffle ratios, and add habitat complexity and diversity. Stream bank stabilization projects will reduce sedimentation from watershed and bank erosion, decrease turbidity levels, and improve water quality for coho salmon over the long-term.

In summary, the proposed action will likely reduce the quantity of coho salmon rearing habitat in the mainstem Klamath River between IGD and the Salmon River, especially in the spring and during below average water years. However, the proposed action is likely to increase the quality of rearing habitat in the action area.

11.6.3.3.1.2 Water Quality

The proposed action is likely to increase water temperature in the mainstem Klamath River between IGD and the Scott River by up to approximately 0.5 °C during the spring (Perry et al. 2011). Below the Scott River mouth, the proposed action’s effects on water temperature in the spring are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in the mainstem Klamath River. In the summer and early fall, any decreases in IGD flows are likely to reduce water temperature in the mainstem Klamath River because reservoir water behind IGD is warmer than the mainstem Klamath River. In addition, the proposed action will likely contribute to adverse effects to the rearing habitat element of coho salmon critical habitat when dissolved oxygen concentrations fall below 8 mg/L in the mainstem Klamath River during the summer.

Restoration activities funded under the proposed action may improve water quality in the tributaries by replacing small irrigation dams with irrigation pumps, which eliminates an impounded area where water temperature elevates and dissolved oxygen concentrations decrease. In addition, the creation of tailwater ponds is likely to improve water temperature, dissolved oxygen concentrations and nutrient concentrations in tributaries by keeping warm and nutrient rich tailwater from directly entering the tributaries.

In summary, the proposed action is likely to adversely affect water quality in the mainstem Klamath River by slightly increasing water temperature during the spring and decreasing dissolved oxygen concentrations during the summer. However, the proposed action is likely to improve water quality in the tributaries by minimizing activities that elevate water temperatures, decrease dissolved oxygen concentrations, and increase nutrients in tributaries.

11.6.4 Response and Risk to the SONCC Coho Salmon ESU Critical Habitat

Many of the physical and biological features that are essential for the conservation of SONCC coho salmon are currently degraded. As a result of implementing the proposed action, some of those physical and biological features will likely remain degraded, while in some cases improvements may occur, especially in the Klamath River tributaries near IGD. The conservation value of many of the physical and biological features in the tributaries of the Klamath River will likely be enhanced where restoration activities occur under the proposed action and other programs. After factoring the restoration activities under the proposed action, the environmental baseline and the status of SONCC coho salmon ESU critical habitat, any remaining adverse effects resulting from the proposed action to the quantity and quality of the essential habitat types are not likely to reduce the overall conservation value of critical habitat at the diversity stratum or ESU.

11.7 Conclusion

After considering the best available scientific and commercial information, the current condition of coho salmon critical habitat, the environmental baseline for the action area, the effects of the proposed action, and cumulative effects in the action area, it is NMFS’ biological opinion that the action, as proposed, is not likely to result in the destruction or adverse modification of critical habitat for the SONCC coho salmon ESU.

12 SONCC COHO SALMON ESU

NMFS has determined that the proposed action may adversely affect the SONCC coho salmon ESU. Therefore, this BiOp analyzes the effects of the proposed action on the SONCC coho salmon ESU using the following analytical approach.

12.1 Analytical Approach

Pursuant to section 7(a)(2) of the ESA, Federal agencies are directed to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species. The implementing regulations for section 7 of the ESA (50 CFR. 402.02) define "jeopardize the continued existence of" to mean "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." In addition to the concept of the natural flow regime, the flow and rearing habitat analyses, the evidence available for consultation, and the critical assumptions discussed in the *SONCC Coho Salmon Critical Habitat* section (i.e., section 11.1.5), NMFS uses the following assessment framework for the SONCC coho salmon ESU.

12.1.1 Overview of NMFS' Assessment Framework

NMFS uses a series of sequential analyses to assess the effects of federal actions on endangered and threatened species and designated critical habitat. The first analysis identifies those physical, chemical, or biotic aspects of the proposed action that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (NMFS uses the term "potential stressors" for these aspects of an action). As part of this step, NMFS identifies the spatial extent of any potential stressors and recognizes that the spatial extent of those stressors may change with time (the spatial extent of these stressors is the "action area" for a consultation) within the action area.

The second step of the analyses starts by determining whether a listed species is likely to occur in the same space and at the same time as these potential stressors. If NMFS concludes that such co-occurrence is likely, NMFS then estimates the nature of that co-occurrence (these represent the *exposure analyses*). In this step of the analyses, NMFS identifies the number and age (or life stage) of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

Once NMFS identifies which listed species and its life stage(s) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, NMFS determines whether and how those listed species and life stage(s) are likely to respond given their exposure (these represent the *response analyses*). The final steps of NMFS' analyses are establishing the risks those responses pose to listed species and their life stages.

12.1.1.1 Risk Analyses for Endangered and Threatened Species

NMFS' jeopardy determination must be based on an action's effects on the continued existence of the listed species, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

NMFS' risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. NMFS identifies the probable risks that actions pose to listed individuals that are likely to be exposed to an action's effects. NMFS then integrates those individuals' risks to identify consequences to the populations those individuals represent. NMFS' analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

NMFS measures risks to listed individuals using the individual's reproductive success which integrates survival and longevity with current and future reproductive success. In particular, NMFS examines the best available scientific and commercial data to determine if an individual's probable response to stressors produced by an action would reasonably be expected to reduce the individual's current or expected future reproductive success by one or more of the following: increasing the individual's likelihood of dying prematurely, having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, reducing the number of times an individual is likely to reproduce over its reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena (Stearns 1992, McGraw and Caswell 1996, Newton and Rothery 1997, Clutton-Brock 1998, Brommer 2000, Brommer et al. 1998, 2002; Roff 2002, Oli and Dobson 2003, Turchin 2003, Kotiaho et al. 2005, Coulson et al. 2006).

When individuals of a listed species are expected to have reduced future reproductive success or reductions in the rates at which they grow, mature, or become reproductively active, NMFS would expect those reductions, if many individuals are affected, to also reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables NMFS derive from them) is a *necessary* condition for increasing a population's extinction risk, which is itself a *necessary* condition for increasing a species' extinction risk.

NMFS equates the risk of extinction of the species with the "likelihood of both the survival and recovery of a listed species in the wild" for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA because survival and recovery are conditions on a continuum with no bright dividing lines. Similar to a species with a low likelihood of both survival and recovery, a species with a high risk of extinction does not equate to a species that lacks the potential to become viable. Instead, a high risk of extinction indicates that the species faces significant risks from internal and external processes and threats that can drive a species to extinction. Therefore, NMFS' jeopardy assessment focuses on whether a proposed action appreciably increases extinction risk, which is a surrogate for appreciable reduction in the likelihood of both the survival and recovery of a listed species in the wild.

On the other hand, when listed species exposed to an action's effects are *not* expected to experience adverse effects, NMFS would not expect the action to have adverse consequences on the extinction risk of the populations those individuals represent or the species those populations comprise (for example, see Anderson 2000, Mills and Beatty 1979, Stearns 1992). If NMFS concludes that listed species are *not* likely to be adversely affected, NMFS would conclude the assessment.

12.1.1.1.1 Effects Analysis for the SONCC coho salmon ESU

For the SONCC coho salmon ESU, the effects analysis is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity stratum, and ESU (Figure 12.1). The guiding principle behind this effects analysis is that the viability of a species (e.g., ESU) is dependent on the viability of the diversity strata that compose that species; the viability of a diversity stratum is dependent on the viability of most independent populations that compose that stratum and the spatial distribution of those viable populations; and the viability of the population is dependent on the fitness and survival of individuals at the life stage scale. The SONCC coho salmon ESU life cycle includes the following life stages and behaviors, which will be evaluated for potential effects resulting from the proposed action: adult migration, spawning, embryo incubation, juvenile rearing, and smolt outmigration.

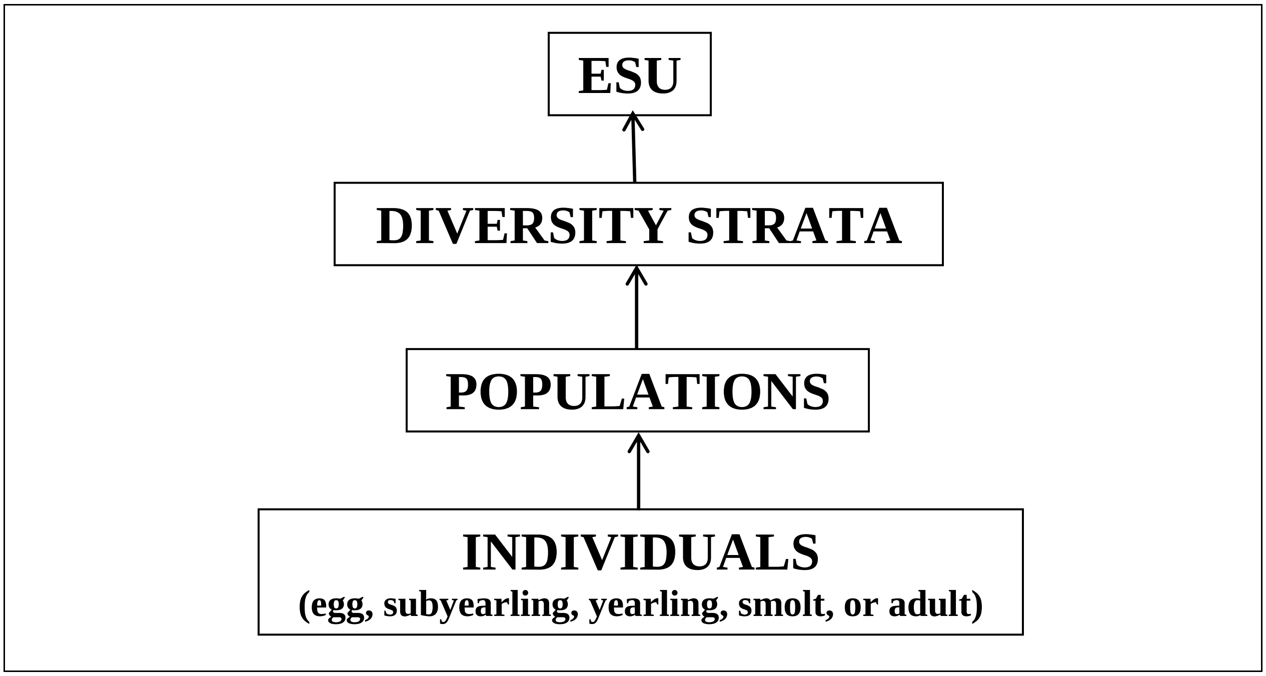

Figure 12.1. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for the SONCC coho salmon ESU.

12.1.1.1.2 Viable Salmonid Populations Framework for Coho Salmon

In order to assess the status, trend, and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. For Pacific salmon, McElhany et al. (2000) defined a viable salmonid population (VSP) as an independent population that has a negligible probability of extinction over a 100-year time frame. The VSP concept provides guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as an ESU or DPS. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). Therefore, these four VSP parameters were used to evaluate the extinction risk of the SONCC coho salmon ESU.

Population size provides an indication of the type of extinction risk that a population faces. For instance, smaller populations are at a greater risk of extinction than large populations because the processes that affect populations operate differently in small populations than in large populations (McElhany et al. 2000). One risk of low population sizes is depensation. Depensation occurs when populations are reduced to very low densities and per capita growth rates decrease as a result of a variety of mechanisms [e.g., failure to find mates and therefore reduced probability of fertilization, failure to saturate predator populations (Liermann and Hilborn 2001)]. While the Allee effect (Allee et al. 1949) is more commonly used in general biological literature, depensation is used here because this term is most often used in fisheries literature (Liermann and Hilborn 2001). Depensation results in negative feedback that accelerates a decline toward extinction (Williams et al. 2008).

The productivity of a population (i.e., production over the entire life cycle) can reflect conditions (e.g., environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany et al. 2000). In general, declining productivity can lead to declining population abundance. Understanding the spatial structure of a population is important because the spatial structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment (McElhany et al. 2000).

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more diverse a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany et al. 2000). However, when diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

Because some of the VSP parameters are related or overlap, the evaluation is at times unavoidably repetitive. Viable ESUs are defined by some combination of multiple populations, at least some of which exceed "viable" thresholds, and that have appropriate geographic distribution, resiliency from catastrophic events, and diversity of life histories and other genetic expression.

A viable population (or species) is not necessarily one that has recovered as defined under the ESA. To meet recovery standards, a species may need to achieve greater resiliency to allow for activities such as commercial harvest and the existing threat regime would need to be abated or ameliorated as detailed in a recovery plan. Accordingly, NMFS evaluates the current status of the species to diagnose how near, or far, the species is from a viable state because it is an important metric indicative of a self-sustaining species in the wild. However, NMFS also considers the ability of the species to recover in light of its current condition and the status of the existing and future threat regime. Generally, NMFS folds this consideration of current condition and ability to recover into a conclusion regarding the "risk of extinction" of the population or species.

NMFS uses the concepts of VSP as an organizing framework in this BiOp to systematically examine the complex linkages between the proposed action effects and VSP parameters while also considering and incorporating natural risk factors such as climate change and ocean conditions. These VSP parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of coho salmon (McElhany et al. 2000). These four parameters are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02) and are used as surrogates for numbers, reproduction, and distribution. The fourth VSP parameter, diversity, relates to all three jeopardy criteria. For example, numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-level scales.

12.2 Status of the Species

In this section, NMFS develops a rangewide assessment of the condition of the species (i.e., its status). NMFS describes the factors, such as life history, distribution, population sizes and trends, and evidence of resiliency and redundancy, which help determine the likelihood of both survival and recovery of the species. In doing so, NMFS describes how vulnerable the species is to extinction.

NMFS listed the SONCC coho salmon ESU, which includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon in the north to Punta Gorda, California in the south, as a threatened species in 1997 (62 FR 24588; May 6, 1997). In 2005, NMFS reaffirmed its status as a threatened species and also listed three hatchery stocks as part of the ESU (70 FR 37160; June 28, 2005). Analysis of recent genetic data from coho salmon in this and adjacent ESUs (Oregon Coast ESU to the north and Central California Coast ESU to the south) supports the existing boundaries of the SONCC coho salmon ESU boundary (Stout et al. 2010, Williams et al. 2011). NMFS recently completed a status review of the SONCC coho salmon ESU (Ly and Ruddy 2011) and determined that the ESU, although trending in declining abundance, should remain listed as threatened.

12.2.1 Life History

Coho salmon is an anadromous fish species that generally exhibits a relatively simple 3-year life cycle. Adults typically begin their freshwater spawning migration in the late summer and fall, spawn by mid-winter, and then die. Spawning occurs mainly in November and December in small streams that flow directly into the ocean, or tributaries and headwater creeks of larger rivers (Sandercock 1991, Moyle 2002). Depending on river temperatures, eggs incubate in ‘‘redds’’ (gravel nests excavated by spawning females) for 1.5 to 4 months before hatching as ‘‘alevins’’ (a larval life stage dependent on food stored in a yolk sac). Following yolk sac absorption, alevins emerge from the gravel as young juveniles or ‘‘fry’’ and begin actively feeding. Coho fry typically transition to the juvenile stage by about mid-June, and both stages are collectively referred to as “young of the year.” Juvenile rearing usually occurs in tributary streams with a gradient of 3 percent or less, although they may move up streams with as much as five percent gradient (Agrawal et al 2005, Leidy et al. 2005). Juveniles have been found in streams as small as 1 to 2 meters wide, and may spend 1 to 2 years rearing in freshwater (Bell and Duffy 2007), or emigrate to an estuary shortly after emerging from spawning gravels (Tschaplinski 1988). Coho salmon juveniles are also known to “redistribute” into non-natal rearing streams, lakes, or ponds, often following rainstorms, where they continue to rear (Peterson 1982). Juveniles rear in fresh water for up to 15 months, then migrate to the ocean as ‘smolts’ in the spring. Coho salmon typically spend about another 15 months in the ocean before returning to their natal stream to spawn as 3 year-olds. Some precocious males, called ‘‘jacks,’’ return to spawn after only 6 months at sea.

12.2.2 Distribution

Coho salmon were historically distributed throughout the North Pacific Ocean from central California to Point Hope, Alaska, through the Aleutian Islands, and from the Anadyr River, Russia, south to Hokkaido, Japan. Historically, this species probably inhabited most coastal streams in Washington, Oregon, and northern and central California. NMFS identified six coho salmon evolutionarily significant units in Washington, Oregon, and California (Weitkamp et al. 1995), including the SONCC ESU. The SONCC coho salmon ESU is composed of 41[8] populations between Punta Gorda, California and Cape Blanco, Oregon (Figure 12.2; NMFS 2012a).

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[8] Although Williams et al. (2006) recognizes a total of 45 populations in the ESU, NMFS subsequently corrected errors in the IP-km values, which result in a total of 41 populations.

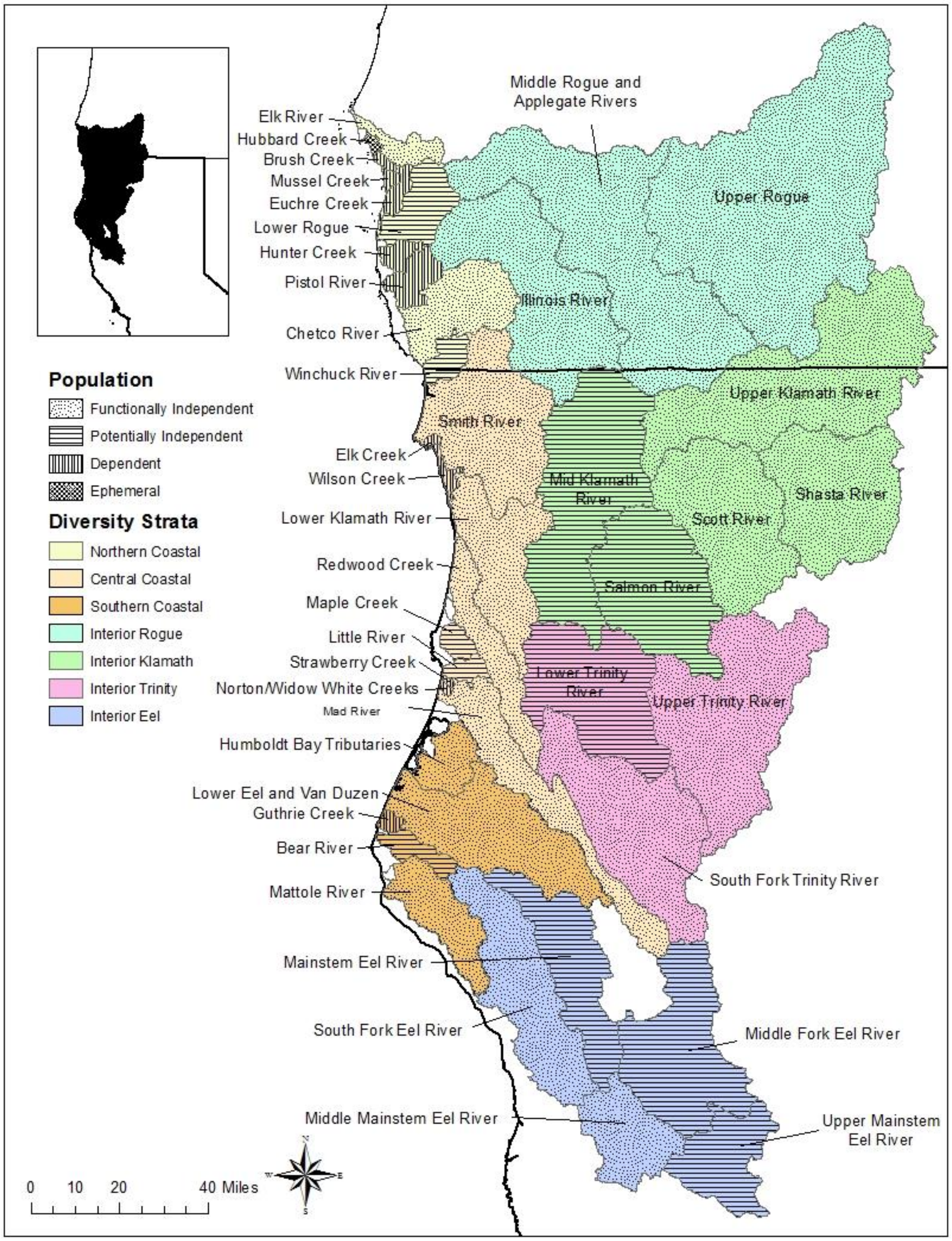


Figure 12.2. Historic population structure of the SONCC coho salmon ESU (modified from Williams et al. 2006).

12.2.3 Conservation Needs of the Species

At the ESU level, SONCC coho salmon must demonstrate representation, redundancy, connectivity, and resiliency. Representation relates to the genetic and life history diversity of the ESU, which is needed to conserve its adaptive capacity. Redundancy addresses the need to have a sufficient number of populations so the ESU can withstand catastrophic events (NMFS 2010c). Connectivity refers to the dispersal capacity of populations to maintain long-term demographic and genetic processes. Resiliency is the ability of populations to withstand natural and human-caused stochastic events, and it depends on sufficient abundance and productivity. The following attributes are necessary for the SONCC coho salmon ESU to demonstrate representation, redundancy, connectivity, and resiliency: core populations must be viable and well distributed; non-core populations must not have a risk of extinction; and dependent populations must have functioning habitat for all life stages of coho salmon (Williams et al 2008, NMFS 2012a).

In order to achieve viable core populations and low or moderate risk of extinction for non-core populations, good quality habitat must be available to support SONCC coho salmon populations (NMFS 2012a). The rationale for having good quality habitat is that NMFS expects that as habitat is restored and key threats are abated, more coho salmon will survive and reproduce. Good quality habitat for coho salmon includes sufficient invertebrate organisms for food; cool, flowing waters; high dissolved oxygen concentrations in rearing and incubation habitats; water with low suspended sediment during the growing season (for visual feeding); clean gravel substrate for reproduction; and unimpeded migratory access to and from spawning and rearing areas. Specific metrics for good quality habitat are defined in NMFS's public draft recovery plan for SONCC coho salmon ESU (NMFS 2012a) using the indicators of aquatic habitat suitability listed in Kier Associates and NMFS (2008) and the disease infection rates summarized by True (2011).

12.2.4 Extinction Risk Criteria

Williams et al. (2008) built on the population structure and the concepts of VSP (McElhany et al. 2000) to establish the extinction risk criteria at the population and ESU scales. The population extinction risk criteria represent an extension of an approach developed by Allendorf et al. (1997), and include metrics related to population abundance (effective population size), population decline, catastrophic decline, spawner density, hatchery influence, and population viability assessment. Populations that fail to satisfy several extinction risk metrics are likely at greater risk than those that fail to satisfy a single metric. A viable population must have a low extinction risk for all of the 6 population metrics (Table 12.1). For a population to be at moderate risk of extinction, the population must meet the moderate risk description for each criterion shown in Table 12.1.

Sharr et al. (2000) modeled the probability of extinction of most Oregon Coast Natural populations and found that as spawner density dropped below 4 fish per mile (2.4 spawners/km), the risk of extinction rises rapidly (Figure 12.3). When Chilcote (1999) tracked the collapse of four coho salmon populations in the Lower Columbia River, they found the depensation threshold was 2.4 spawners/km. Using spawner-recruit relationships from 14 populations of coho salmon, Barrowman et al. (2003) found evidence of depensatory effects when spawner densities are less than 1 adult female per km of river (2 spawners/km).

Wainwright et al. (2008) chose a value of 0.6 spawners/km as the density at which a population of salmon would be very likely to have significant demographic risks. This was the lowest of four bins the Wainwright et al. (2008) workgroup used to populate a decision support system. Williams et al. (2008) essentially chose this value then divided it by 0.6, which is equivalent to the average ratio of IP-km to total km in the SONCC ESU. The resulting value of one adult per IP-km was deemed to be the threshold for high risk of depensation by Williams et al (2008).

Table 12.1. Criteria for assessing extinction risk for SONCC coho salmon populations. For a given population, the highest risk score for any category determines the population's overall extinction risk (Williams et al. 2008).

Criterion	Extinction risk		
	High	Moderate	Low
	- any One of -	- any One of -	- all of -
Effective population size[a]	$N_e \le 50$	$50 < N_e < 500$	$N_e \ge 500$
- or -	*- or -*	*- or -*	*- or -*
Population size per generation	$N_g \le 250$	$250 < N_g < 2500$	$N_g \ge 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophic decline	Order of magnitude decline within one generation	Smaller but significant decline[d]	Not apparent
Spawner density (adults/IP km)	$N_a/IP\ km \le 1$	$1 < N_a/IP\ km <$ MRSD[e]	$N_a/IP\ km \ge$ MRSD[e]
Hatchery influence	Not developed		Hatchery fraction <5%
			- in addition to above -
Extinction risk from PVA	≥20% within 20 yrs	≥5% within 100 yrs but <20 percent within 20 yrs	< 5 percent within 100 yrs[f]

[a] The effective population size (N_e) is the number of breeding individuals in an idealized population that would give rise to the same variance in gene frequency under random genetic drift or the same rate of inbreeding as the population under consideration (Wright 1931); total number spawners per generation (N_g), for SONCC coho salmon the generation time is approximately three years therefore $N_g = 3\ N_a$.

[b] Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size of $N_a \le 500$ spawners (historically small but stable populations not included) or $N_a > 500$ but declining at a rate of ≥10 percent per year over the last two-to-four generations.

[c] Annual spawner abundance N_a has declined to ≤500 spawners, but now stable **or** number of adult spawners (N_a) > 500 but continued downward trend is evident.

[d] Annual spawner abundance decline in one generation < 90 percent but biologically significant (e.g., loss of year class).

[e] MRSD = minimum required spawner density is dependent on the amount of potential habitat available

[f] For population to be considered at low-risk of extinction, all criteria must be satisfied (i.e., not just a PVA). A population viability analysis (PVA) can be also included for consideration, but must estimate an extinction risk <5 percent within 100 years *and* all other criteria must be met. If discrepancies exist between PVA results and other criteria, results need to be thoroughly examined and potential limitations of either approach are carefully identified and examined.

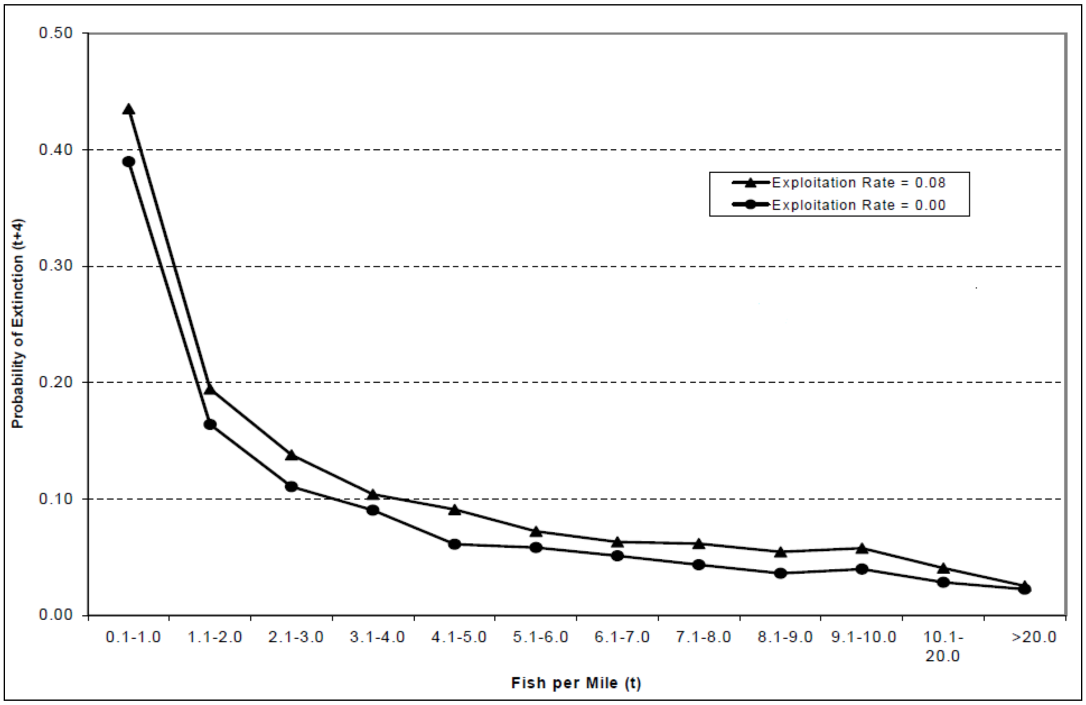


Figure 12.3. Relationship between fish density and extinction probability of coho salmon populations in Oregon coastal basins. Probability applies to four generations as a function of spawner density for exploitation rates of 0.00 and 0.08 (Sharr et al. 2000).

12.2.5 Status and Trend

In order to determine the status and trend of the SONCC coho salmon ESU, NMFS uses the population extinction risk criteria above (Table 12.1) and the concept of a VSP for evaluating populations (McElhany et al. 2000). A VSP is defined as one that has a low risk of extinction over 100 years. As discussed earlier, viable salmonid populations are described in terms of four parameters: abundance, population productivity, spatial structure, and diversity. These parameters are predictors of extinction risk, and reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany et al. 2000). The following subsection provides the evaluation of the current status and trend of the SONCC coho salmon ESU based on the four VSP parameters.

12.2.5.1 Population Abundance

Quantitative population-level estimates of adult spawner abundance spanning more than 9 years are scarce for SONCC ESU coho salmon. Data consists of continuation of a few time series of adult abundance, expansion of efforts in coastal basins of Oregon to include SONCC ESU coho salmon populations, and continuation and addition of several "population" scale monitoring efforts in California. Other than the Shasta River and Scott River adult counts, reliable current time series of naturally produced adult spawners are not available for the California portion of the SONCC ESU at the "population" scale.

Although long-term data on coho salmon abundance are scarce, the available monitoring data indicate that spawner abundance has declined for populations in this ESU. The number of adult coho salmon at the video weir on the Shasta River has decreased since 2001 (Figure 12.4). Available time series data on the Shasta River show low adult returns, of which two out of three cohorts are considered to be nearly extirpated (Chesney et al. 2009). The Shasta River population has declined in abundance by almost 50 percent from one generation to the next (Williams et al. 2011).

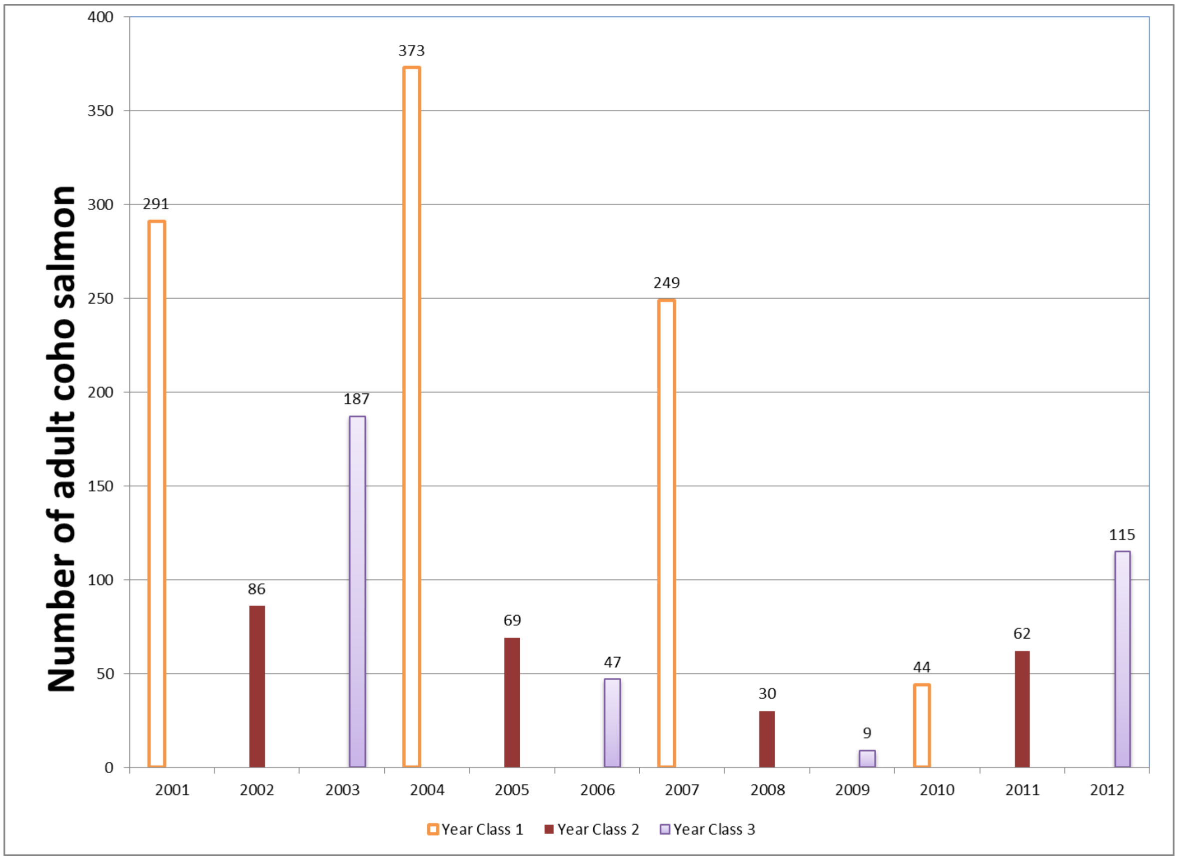


Figure 12.4. Estimates of adult coho salmon in the Shasta River from 2001 to 2012 from video weir data (Chesney and Knechtle 2011a, Knechtle 2013).

Two partial counts from Prairie Creek, a tributary of Redwood Creek, and Freshwater Creek, a tributary of Humboldt Bay show a negative trend (Figures 12.5 and 12.6, respectively). Data from the Rogue River basin also show recent negative trends. Estimates from Huntley Park in the Rogue River basin show a strong return year in 2004, followed by a decline to 394 fish in 2008, the lowest estimate since 1993 and the second lowest going back to 1980 in the time series (Figure 12.7). The Huntley Park seine estimates in the lower Rogue River provide the best overall assessment of naturally produced coho salmon spawner abundance in the Rogue River basin (Oregon Department of Fish and Wildlife [ODFW] 2005). Four independent populations contribute to this count (Lower Rogue River, Illinois River, Middle Rogue and Applegate rivers, and Upper Rogue River). The 12-year average estimated wild adult coho salmon in the Rogue River basin between 1998 and 2009 is 7414, which is well below historic abundance. Based on extrapolations from cannery pack, the Rogue River had an estimated adult coho salmon abundance of 114,000 in the late 1800s (Meengs and Lackey 2005).

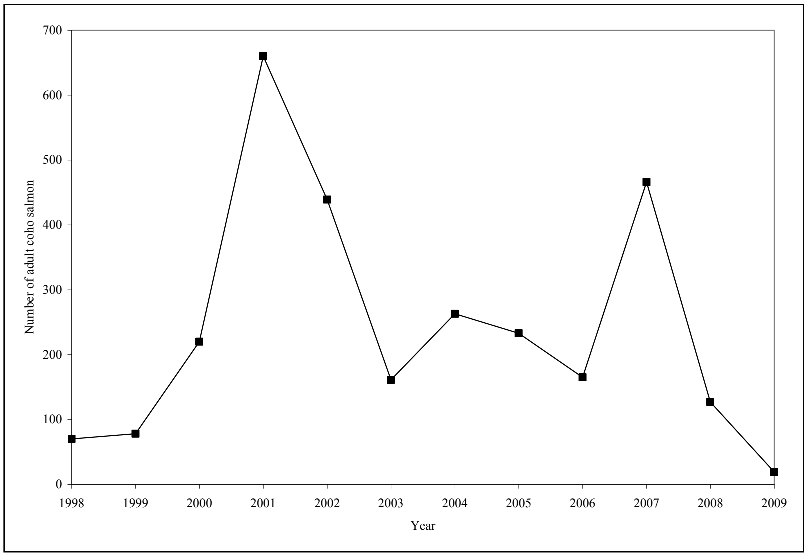


Figure 12.5. Estimate of spawning coho salmon in Prairie Creek, a tributary to Redwood Creek (Humboldt County, California) from 1998 to 2009 (Williams et al. 2011).

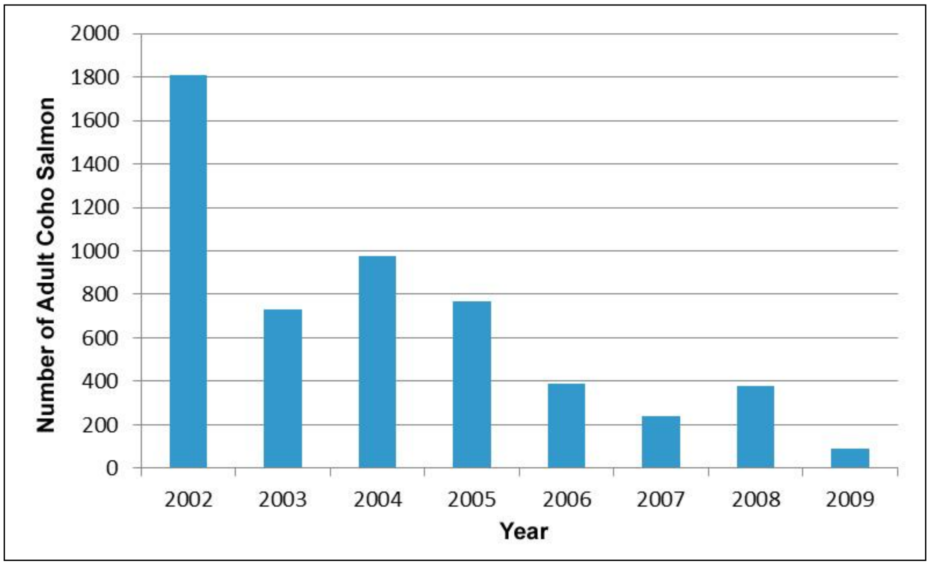


Figure 12.6. Adult coho salmon estimate for Freshwater Creek, a tributary to Humboldt Bay, from 2002 to 2009 (Ricker and Anderson 2011).

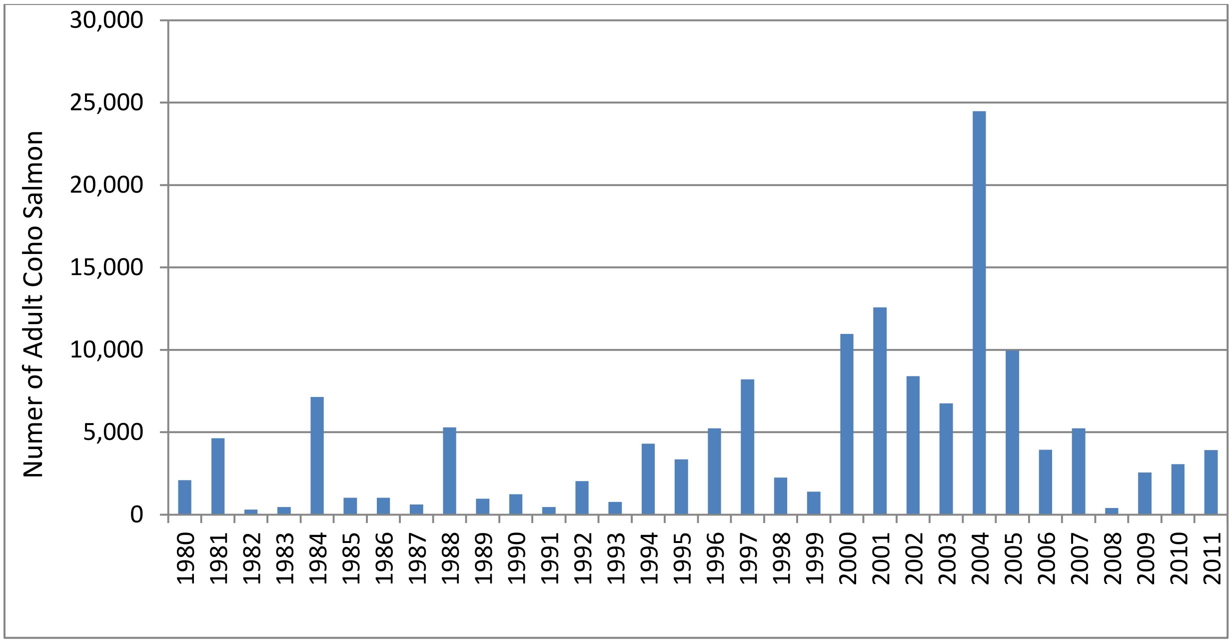


Figure 12.7. Estimated number of wild adult coho salmon in the Rogue River basin based on Huntley Park sampling from 1980 to 2011 (ODFW 2013).

Though population-level estimates of abundance for most independent populations are lacking, the best available data indicate that none of the seven diversity strata appears to support a single viable population as defined by the extinction risk criteria (Table 12.1). In fact, most of the 30 independent populations in the ESU are at high risk of extinction because they are below or likely below their depensation threshold.

In addition, populations that are under depensation have increased likelihood of being extirpated. Extirpations have already occurred in the Eel River basin and are likely in the interior Klamath River basin for one or all year classes (e.g., Shasta and Scott rivers), Bear River, and Mattole River. Coho salmon spawners in the Eel River watershed, which historically supported significant spawners (e.g., 50,000 to 100,000 per year; Yoshiyama and Moyle 2010), have declined. Yoshiyama and Moyle (2010) concluded that coho salmon populations in the Eel River basin appear to be headed for extirpation by 2025. One population contains critically low numbers (i.e., Upper Mainstem Eel River; with only a total of 7 coho salmon adults counted at the Van Arsdale Fish Station in over six decades; Jahn 2010). Although long term spawner data are not available, both NMFS and CDFW believe the Lower Eel/Van Duzen River, Middle Mainstem Eel and Mainstem Eel River populations are likely below the depensation threshold, and thus are at a high risk of extinction. The only population in the Eel River basin that is likely to be above its depensation threshold is the South Fork Eel River, which also has significantly declined from historical numbers (Figure 12.8).

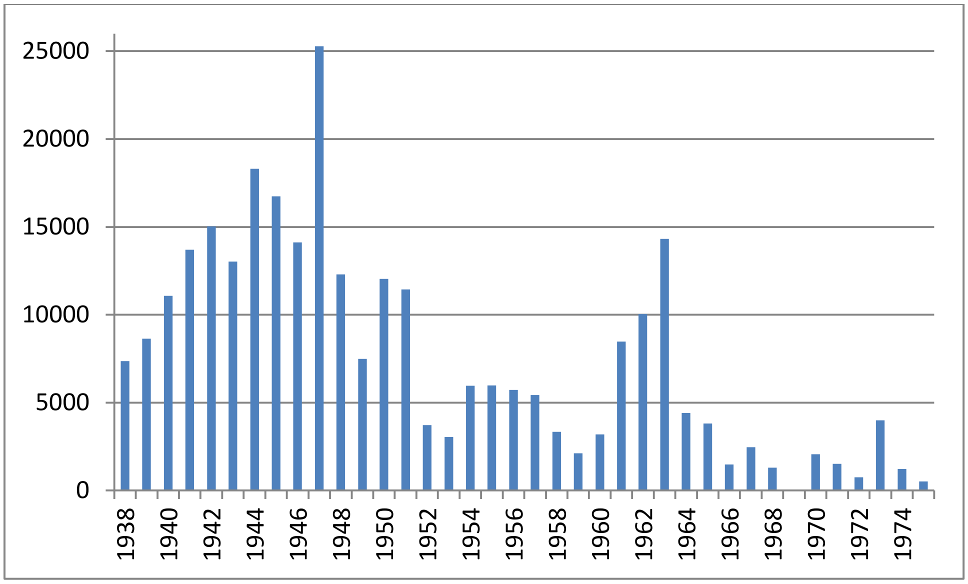


Figure 12.8. Fish counts from 1938 to 1975 at Benbow Fish Station in the South Fork Eel River. Data from Murphy 1952, Gibbs 1964, and McEwan 1994.

In addition to the Eel River basin, two other independent populations south of the Eel River basin, the Bear River and Mattole River populations, have similar trajectories. The Bear River population is likely extirpated or severely depressed. Despite multiple surveys over the years, no coho salmon have been found in the Bear River watershed (Ricker 2002, Garwood 2012). In 1996 and 2000, the CDFW surveyed most tributaries of the Bear River, and did not find any coho salmon (CDFG 2004b). In addition, CDFW sampled the mainstem and South Fork Bear River between 2001 and 2003 and found no coho salmon (Garwood 2012). In the Mattole River, surveys of live fish and carcasses since 1994 indicate the population is severely depressed and well below the depensation threshold of 250 spawners. Recent spawner surveys in the Mattole River resulted in only 3 and 9 coho salmon for 2009 and 2010, respectively. These low numbers, along with a recent decline since 2005, indicate that the Mattole River population is at a high risk of extinction.

Because the extinction risk of an ESU depends upon the extinction risk of its constituent independent populations (Williams et al. 2008) and the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable in regard to the abundance parameter.

12.2.5.2 Population Productivity

As discussed above in the population abundance section, available data indicates that many populations have declined, which may reflect a reduction in productivity. For instance, the Shasta River population has declined in abundance by almost 50 percent from one generation to the next (Williams et al. 2011). Two partial counts from Prairie Creek, a tributary of Redwood Creek, and Freshwater Creek, a tributary of Humboldt Bay show a negative trend. Data from the Rogue River basin also show recent negative trends. In general, SONCC coho salmon have declined substantially from historic levels. Productivity does not appear to be sufficient to maintain viable abundances in many SONCC coho salmon populations. Because productivity appears to be negative for most SONCC ESU coho salmon populations, this ESU is not currently viable in regard to population productivity.

12.2.5.3 Spatial Structure

Data is inadequate to determine whether the spatial distribution of SONCC ESU coho salmon has changed since 2005. In 2005, Good et al. (2005) noted that they had strong indications that breeding groups have been lost from a significant percentage of streams within their historical range. Relatively low levels of observed presence in historically occupied coho salmon streams (35 to 60 percent from 1986 to 2000, Figure 12.9) indicate continued low abundance in the California portion of the SONCC coho salmon ESU. The relatively high occupancy rate of historical streams observed in brood year 2001 suggests that much habitat remains accessible to coho salmon (70 FR 37160; June 28, 2005). Brown et al. (1994) found survey information on 115 streams within the SONCC coho salmon ESU, of which 73 (64 percent) still supported coho salmon runs while 42 (36 percent) did not. The streams Brown et al. (1994) identified as lacking coho salmon runs were all tributaries of the Klamath River and Eel River basins. CDFG (2002a) reported a decline in SONCC ESU coho salmon occupancy, with the percent reduction dependent on the data sets used.

Although there is considerable year-to-year variation in estimated occupancy rates, it appears that there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to 2000 (Good et al. 2005). However, the number of streams and rivers currently supporting coho salmon in this ESU has been greatly reduced from historical levels, and watershed-specific extirpations of coho salmon have been documented (Brown et al.1994, CDFG 2004b, Good et al. 2005, Moyle et al. 2008, Yoshiyama and Moyle 2010). In summary, information on the SONCC ESU of coho salmon indicates that their distribution within the ESU has been reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which they are now absent (NMFS 2001b). However, extant populations can still be found in all major river basins within the ESU (70 FR 37160; June 28, 2005).

Given that all diversity strata are occupied (Williams et al. 2011), the spatial structure of the SONCC coho salmon ESU is broadly distributed throughout its range. However, extirpations, loss of brood years, and sharp declines in abundance (in some cases to zero) of SONCC coho salmon in several streams throughout the ESU indicate that the SONCC coho salmon's spatial structure is more fragmented at the population-level than at the ESU scale.

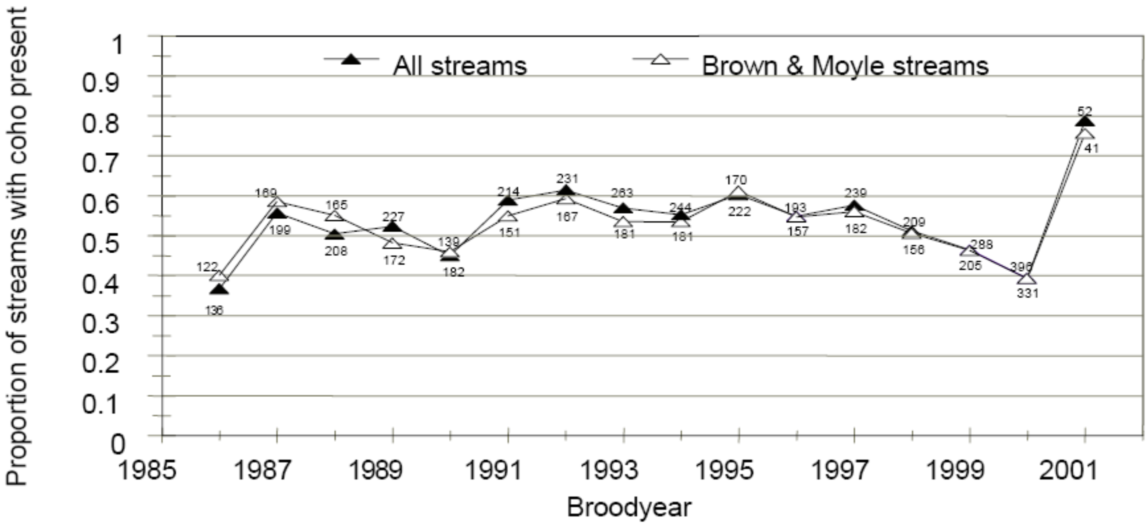


Figure 12.9. Proportion of surveyed streams where coho salmon were detected (Good et al. 2005). The number of streams surveyed is shown next to data.

12.2.5.4 Diversity

The primary factors affecting the diversity of SONCC ESU coho salmon appear to be low population abundance and the influence of hatcheries and out-of-basin introductions. Although the operation of a hatchery tends to increase the abundance of returning adults (70 FR 37160; June 28, 2005), the reproductive success of hatchery-born salmonids spawning in the wild can be significantly less than that of naturally produced fish (Araki et al. 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the overall productivity of the population, as demonstrated by Chilcote (2003). Williams et al. (2008) considered a population to be at least at a moderate risk of extinction if the contribution of hatchery coho salmon spawning in the wild exceeds 5 percent. Populations have a lower risk of extinction if no or negligible ecological or genetic effects are demonstrated as a result of past or current hatchery operations. Because the main stocks in the SONCC coho salmon ESU (i.e., Rogue River, Klamath River, and Trinity River) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp et al. 1995; Good et al. 2005), many of these populations are at high risk of extinction relative to the genetic diversity parameter.

In addition, some populations are extirpated or nearly extirpated (i.e., Middle Fork Eel, Bear River, Upper Mainstem Eel) and some brood years have low abundance or may even be absent in some areas (e.g., Shasta River, Scott River, Mattole River, Mainstem Eel River), which further restricts the diversity present in the ESU. The ESU's current genetic variability and variation in life history likely contribute significantly to long-term risk of extinction. Given the recent trends in abundance across the ESU, the genetic and life history diversity of populations is likely very low and is inadequate to contribute to a viable ESU.

12.2.5.5 Viability Summary

Though population-level estimates of abundance for most independent populations are lacking, the best available data indicate that none of the seven diversity strata appears to support a single viable population as defined by Williams et al's (2008) viability criteria. Integrating the four VSP parameters into the population viability criteria, as many as 21 out of 30 independent populations are at high risk of extinction and 9 are at moderate risk of extinction (Table 12.2).

Table 12.2. SONCC coho salmon ESU independent populations and their risk of extinction.

Stratum	Independent Populations	Extinction Risk	Population Viability Metric (Williams et al. 2008)
Northern Coastal Basin	Elk River	High	Population likely below depensation threshold[1]
	Lower Rogue River	High	
	Chetco River	High	
	Winchuck River	High	
Interior Rogue River	Illinois River	Moderate	Population abundance of wild coho salmon the past 3 years likely above the depensation threshold, but below the low risk spawner threshold. Rogue River populations reflect data from Huntley Park counts, which represents the entire Rogue River basin. NMFS assumes coho salmon from the three Rogue River populations are equally captured at Huntley Park, and the estimate represents the populations fairly evenly.
	Middle Rogue/Applegate rivers	Moderate	
	Upper Rogue River	Moderate	Population above depensation threshold, based on data from Gold Ray Dam.
Central Coastal Basin	Smith River	High	Population likely below depensation threshold[1]
	Lower Klamath River	High	Population likely below depensation threshold[1]
	Redwood Creek	High	Population likely below depensation threshold[1]
	Maple Creek/Big Lagoon	High	Population likely below depensation threshold[1]
	Little River	Moderate	Population likely above depensation threshold[1]
	Mad River	High	Population likely below depensation threshold[1]
Interior Klamath	Middle Klamath River	Moderate	Population likely above depensation threshold[1]
	Upper Klamath River	High	Population below depensation threshold[1] and hatchery fraction likely >5 percent
	Shasta River	High	
	Scott River	Moderate	Population above depensation threshold[1]
	Salmon River	High	Population below depensation threshold[1]
Interior Trinity	Lower Trinity River	Moderate	Population likely above depensation threshold[1] but hatchery fraction >5 percent
	South Fork Trinity River	High	Population likely below depensation threshold[1]
	Upper Trinity River	Moderate	Though above the depensation threshold, this population's hatchery fraction >5 percent
South Coastal Basin	Humboldt Bay tributaries	High	Though above the depensation threshold, this population has declined within the last two generations or is projected to decline within the next two generations (based on Freshwater Creek data if current trends continue) to annual run size ≤ 500 spawners.
	Lower Eel and Van Duzen rivers	High	Population likely below depensation threshold[1]

Stratum	Independent Populations	Extinction Risk	Population Viability Metric (Williams et al. 2008)
	Bear River	High	Population below depensation threshold[1]
	Mattole River	High	
Interior Eel	Mainstem Eel River	High	Population likely below depensation threshold[1]
	Middle Mainstem Eel River	High	
	Upper Mainstem Eel River	High	Population below depensation threshold[1]
	Middle Fork Eel River	High	
	South Fork Eel River	Moderate	Population likely above depensation threshold[1]

[1] Based on average spawner abundance over the past three years or best professional judgment of NMFS staff.

Based on the above discussion of the population viability parameters, and qualitative viability criteria presented in Williams et al. (2008), NMFS concludes that the SONCC coho salmon ESU is currently not viable and is at a high risk of extinction.

The precipitous decline in abundance from historical levels and the poor status of population viability metrics in general are the main factors behind the extinction risk faced by SONCC coho salmon. NMFS believes the main cause of the recent decline is likely poor ocean conditions and the widespread degradation of habitat, particularly those habitat attributes that support the freshwater rearing life-stages of the species.

12.2.6 Factors Responsible for the Current Status of SONCC Coho Salmon ESU

When the SONCC ESU was listed, the major factors identified as responsible for the decline of coho salmon in Oregon and California and/or degradation of their habitat included logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, artificial propagation, over-fishing, water withdrawals, and unscreened diversions for irrigation (62 FR 24588; May 6, 1997). The lack, or inadequacy, of protective measures in existing regulatory mechanisms, including land management plans (e.g., State Forest Practice Rules), Clean Water Act section 404 regulatory activities, urban growth management, and harvest and hatchery management, contributed by varying degrees to the decline of coho salmon. Below, some of these major activities are covered in more detail.

In addition to the factors responsible for the current status of the SONCC coho salmon ESU critical habitat, ocean conditions, reduction in marine derived nutrients, artificial propagation, commercial fisheries and small population size also affect the current status of SONCC coho salmon ESU.

12.2.6.1 Ocean Conditions

Variability in ocean productivity has been shown to affect fisheries production both positively and negatively (Chavez et al. 2003). Beamish and Bouillion (1993) showed a strong correlation between North Pacific salmon production and marine environmental factors from 1925 to 1989. Coho salmon marine survival corresponds with periods of alternating cold and warm ocean conditions. Cold conditions are generally good for coho salmon, while warm conditions are not (Peterson et al. 2010). Unusually warm ocean surface temperatures and associated changes in coastal currents and upwelling, known as El Niño conditions result in ecosystem alterations such as reductions in primary and secondary productivity and changes in prey and predator species distributions. Coho salmon along the Oregon and California coast are likely to be sensitive to upwelling patterns because these regions lack extensive bays, straits, and estuaries, which could buffer adverse oceanographic effects. The paucity of high quality near-shore habitat, coupled with variable ocean conditions, makes freshwater rearing habitat essential for the survival and persistence of many coho salmon populations.

Data from hatchery fish at Cole Rivers Hatchery indicate extremely low marine survival for the 2005 and 2006 brood years (i.e., 0.05 and 0.07 percent, respectively) compared with an average of approximately 2.2 percent between 2000 and 2004 (Figure 12.10; Williams et al. 2011). Strong upwelling in the spring of 2007 resulted in better ocean conditions (MacFarlane et al. 2008, Peterson et al. 2010) for the 2005 coho salmon brood year. Marine conditions in 2008 and 2009 have also been favorable (Figure 12.11), with 2008 being the best in the last 13 years (NMFS 2013). Because salmon productivity and survival are correlated with ocean conditions (Pearcy 1992 *in* Zabel et al. 2006, Beamish & Bouillon 1993, Peterson et al. 2010), favorable marine conditions usually corresponds with increased marine survival.

Ocean conditions in 2011 and 2012 have improved over the recent past. However, improved ocean conditions do not necessarily result in improved marine survival and higher adult returns for SONCC coho salmon ESU. For instance, in 2008, adult spawner populations (2005 brood year) within the Oregon Coast coho salmon ESU rebounded from recent declines (Lewis et al. 2009), while many SONCC coho salmon ESU populations, including Rogue River populations declined to near record low numbers.

Bradford et al. (2000) found that the average coastal coho salmon population will be unable to sustain itself when marine survival rates fall below about 3 percent. Ocean conditions are not necessarily the only influence of marine survival; however, if marine survival is below three percent, the SONCC coho salmon ESU will have difficulty sustaining itself. Therefore, poor ocean conditions and low marine survival poses a significant threat to the SONCC coho salmon ESU.

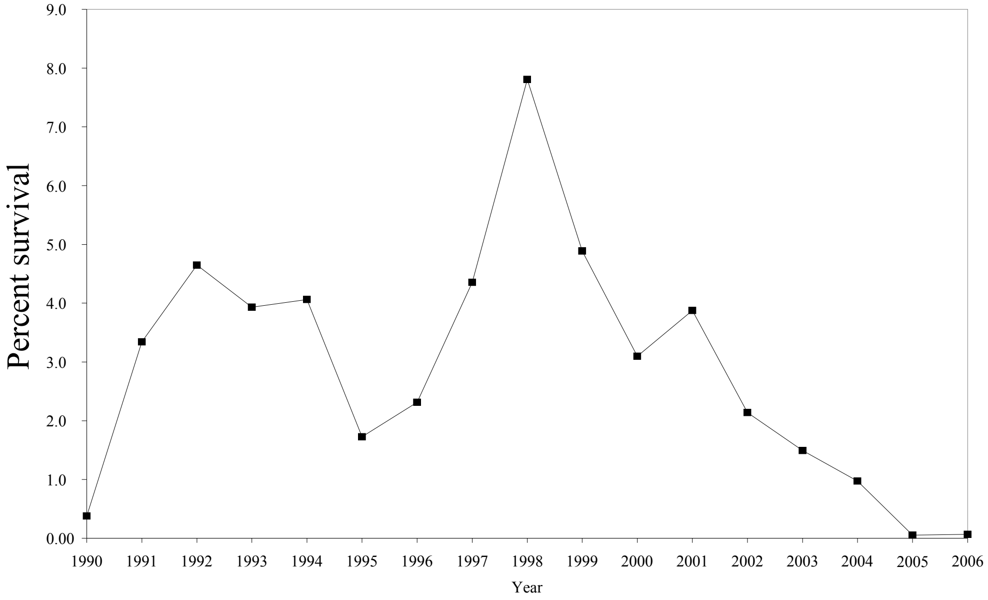
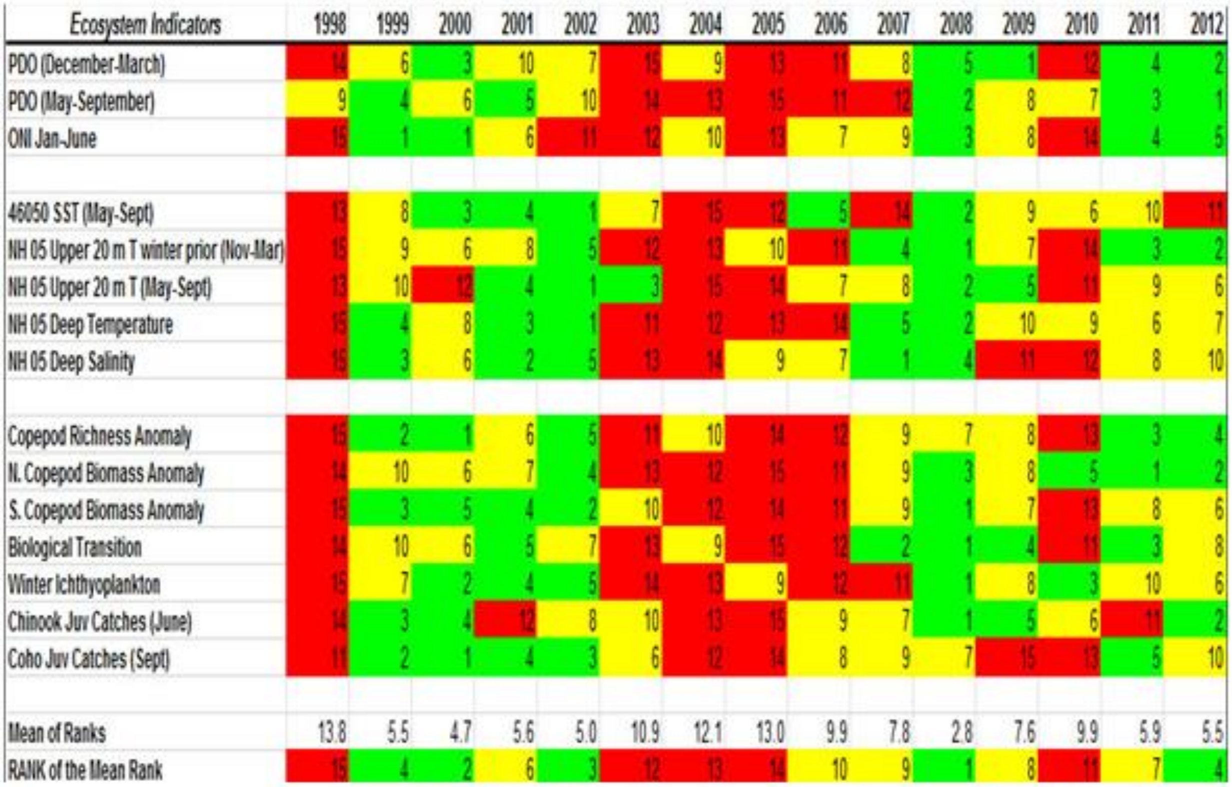


Figure 12.10. Survival of hatchery fish returning to Cole Rivers Hatchery (Rogue River) based on coded-wire-tag returns, broodyears 1990 – 2006 (data from ODFW).



Ecosystem Indicators	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PDO (December-March)	14	6	3	10	7	15	9	13	11	8	5	1	12	4	2
PDO (May-September)	9	4	6	5	10	14	13	15	11	12	2	8	7	3	1
ONI Jan-June	15	1	1	6	11	12	10	13	7	9	3	8	14	4	5
46050 SST (May-Sept)	13	8	3	4	1	7	15	12	5	14	2	9	6	10	11
NH 05 Upper 20 m T winter prior (Nov-Mar)	15	9	6	8	5	12	13	10	11	4	1	7	14	3	2
NH 05 Upper 20 m T (May-Sept)	13	10	12	4	1	3	15	14	7	8	2	5	11	9	6
NH 05 Deep Temperature	15	4	8	3	1	11	12	13	14	5	2	10	9	6	7
NH 05 Deep Salinity	15	3	6	2	5	13	14	9	7	1	4	11	12	8	10
Copepod Richness Anomaly	15	2	1	6	5	11	10	14	12	9	7	8	13	3	4
N. Copepod Biomass Anomaly	14	10	6	7	4	13	12	15	11	9	3	8	5	1	2
S. Copepod Biomass Anomaly	15	3	5	4	2	10	12	14	11	9	1	7	13	8	6
Biological Transition	14	10	6	5	7	13	9	15	12	2	1	4	11	3	8
Winter Ichthyoplankton	15	7	2	4	5	14	13	9	12	11	1	8	3	10	6
Chinook Juv Catches (June)	14	3	4	12	8	10	13	15	9	7	1	5	6	11	2
Coho Juv Catches (Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10
Mean of Ranks	13.8	5.5	4.7	5.6	5.0	10.9	12.1	13.0	9.9	7.8	2.8	7.6	9.9	5.9	5.5
RANK of the Mean Rank	15	4	2	6	3	12	13	14	10	9	1	8	11	7	4

Figure 12.11. Rank scores of ocean ecosystem indicators. Lower numbers indicate better ocean ecosystem conditions, or "green lights" for salmon growth and survival. Figure from NMFS (2013).

12.2.6.2 Marine Derived Nutrients

Marine-derived nutrients are nutrients that are accumulated in the biomass of salmonids while they are in the ocean and are then transferred to their freshwater spawning sites where the salmon die. The return of salmonids to rivers makes a significant contribution to the flora and fauna of both terrestrial and riverine ecosystems (Gresh et al. 2000), and has been shown to be vital for the growth of juvenile salmonids (Bilby et al. 1996, 1998, Giannico and Hinch 2007, Wipfli et al. 2003, 2004, 2010). Evidence of the role of marine-derived nutrients and energy in ecosystems suggests this deficit is likely to result in an ecosystem failure contributing to the downward spiral of salmonid abundance (Bilby et al. 1996). Reduction of marine-derived nutrients to watersheds is a consequence of the past century of decline in salmon abundance (Gresh et al. 2000).

12.2.6.3 Artificial Propagation

Three artificial propagation programs are considered to be part of the ESU: the Cole Rivers Hatchery (Rogue River), Trinity River Hatchery, and Iron Gate Hatchery (IGH, Klamath River) coho programs. These hatcheries produce not only coho salmon but also Chinook salmon and steelhead for release into the wild. Iron Gate (IGH), Trinity River, and Cole Rivers hatcheries release roughly 14,215,000 hatchery salmonids into SONCC coho salmon ESU rivers annually. Annual coho salmon production goals at these hatcheries are 75,000, 500,000, and 200,000, respectively. In addition to the three hatcheries, the Mad River and Rowdy Creek hatcheries in California and the Elk River Hatchery in Oregon produce steelhead and Chinook salmon that can prey on or compete with wild SONCC ESU coho salmon.

Natural populations in these basins are heavily influenced by hatcheries (Weitkamp et al. 1995; Good et al. 2005) through genetic and ecological interactions. Genetic risks associated with out-of-basin and out-of-ESU stock transfers have largely been eliminated. However, two significant genetic concerns remain: 1) the potential for domestication selection in hatchery populations such as the Trinity River, where there is little or no infusion of wild genes, and 2) straying by large numbers of hatchery coho salmon either in basin or out-of-basin. Spawning by hatchery salmonids in rivers and streams is often not controlled (Independent Scientific Advisory Board 2002) and hatchery fish stray into rivers and streams, transferring genes from hatchery populations into naturally spawning populations (Pearse et al. 2007). CDFG (2002b) found that 29 percent of coho salmon carcasses recovered at the Shasta River fish counting facility had left maxillary clips in 2001, indicating that they were progeny from the IGH. The average percentage of hatchery coho salmon carcasses recovered at the Shasta River fish counting facility from 2001, 2003, and 2004 was 16 percent (Ackerman and Cramer 2006). Although the actual percentages of hatchery fish in the river change from year to year and depend largely on natural returns, these data indicate that straying of IGH fish do occur in important tributaries of the Klamath River.

The transferring of genes from hatchery fish can be problematic because hatchery programs have the potential to significantly alter the genetic composition (Reisenbichler and Rubin 1999, Ford 2002), phenotypic traits (Hard et al. 2000; Kostow 2004), and behavior (Berejikian et al. 1996) of reared fish. Genetic interactions between hatchery and naturally produced stocks can decrease the amount of genetic and phenotypic diversity of a species by homogenizing once disparate traits of hatchery and natural fish. The result can be progeny with lower survival (McGinnity et al. 2003, Kostow 2004) and ultimately, a reduction in the reproductive success of the natural stock (Reisenbichler and McIntyre 1977, Chilcote 2003, Araki et al. 2007, Chilcote et al. 2011), potentially compromising the viability of natural stocks via out breeding depression (Reisenbichler and Rubin 1999, HSRG 2004). Williams et al. (2008) considers a population to be at least at moderate risk of extinction if the proportion of naturally spawning fish that are of hatchery origin exceeds 5 percent.

Flagg et al. (2000) found that, depending on the carrying capacity of the system, increasing release numbers of hatchery fish often negatively impacts naturally-produced fish because these fish can get displaced from portions of their habitat. Competition between hatchery and naturally-produced salmonids can also lead to reduced growth of naturally produced fish (McMichael et al. 1997). Kostow et al. (2003) and Kostow and Zhou (2006) found that over the duration of the steelhead hatchery program on the Clackamas River, Oregon, the number of hatchery steelhead in the upper basin regularly caused the total number of steelhead to exceed carrying capacity, triggering density-dependent mechanisms that impacted the natural population. Competition between hatchery and natural salmonids in the ocean can also lead to density-dependent mechanisms that affect natural salmonid populations, especially during periods of poor ocean conditions (Beamish et al. 1997, Levin et al. 2001, Sweeting et al. 2003).

12.2.6.4 Commercial and Recreational Fisheries

12.2.6.4.1 Tribal Fishery

Tribal harvest was not considered to be a major threat to the SONCC coho salmon ESU when the ESU was listed under the ESA (60 FR 38011; July 25, 1995). Klamath basin tribes (Yurok, Hoopa, and Karuk) harvest a relatively small number of coho salmon for subsistence and ceremonial purposes (CDFG 2002b). Coho salmon harvested by Native American tribes is primarily incidental to larger Chinook salmon subsistence fisheries in the Klamath and Trinity rivers. Estimates of the harvest rate for the Yurok fishery are available since 1992, and averaged 4 percent between 1992 and 2005, and 5 percent between 2006 and 2009 (Williams 2010). The average annual harvest rate by the Hoopa Tribe accounts for less than 3 percent of the total number of adult spawners returning to the Trinity River (Naman 2012).

12.2.6.4.2 Non-tribal Commercial Fishery

Commercial fisheries have been identified as a major factor in the decline of the SONCC coho salmon ESU (60 FR 38011; July 25, 1995 and 69 FR 33102; June 14, 2004). However, coho salmon-directed fisheries and coho salmon retention have been prohibited off the coast of California since 1996. Therefore, the SONCC coho salmon ESU ocean exploitation rate is low. Incidental mortality occurs as a result of non-retention impacts in California and Oregon Chinook-directed fisheries and in Oregon’s mark-selective coho fisheries.

The Rogue/Klamath coho salmon ocean exploitation rate forecast time series from 2000 to 2010 (Figure 12.12) is the best available measure of ocean exploitation rate for the SONCC coho salmon ESU. This rate had been stable and averaged 6 percent over 2000 to 2007 prior to falling to 1 percent and 3 percent in 2008 and 2009, respectively, due to closure of nearly all salmon fisheries south of Cape Falcon, Oregon. Preliminary post-season estimates of ocean exploitation rate for 2010 and 2011 are 2.2 and 3.8 percent, respectively (PFMC 2011, 2012). Because of the generally limited Chinook salmon fishery since 2005, NMFS believes the commercial fishery has been a small threat to the SONCC coho salmon ESU.

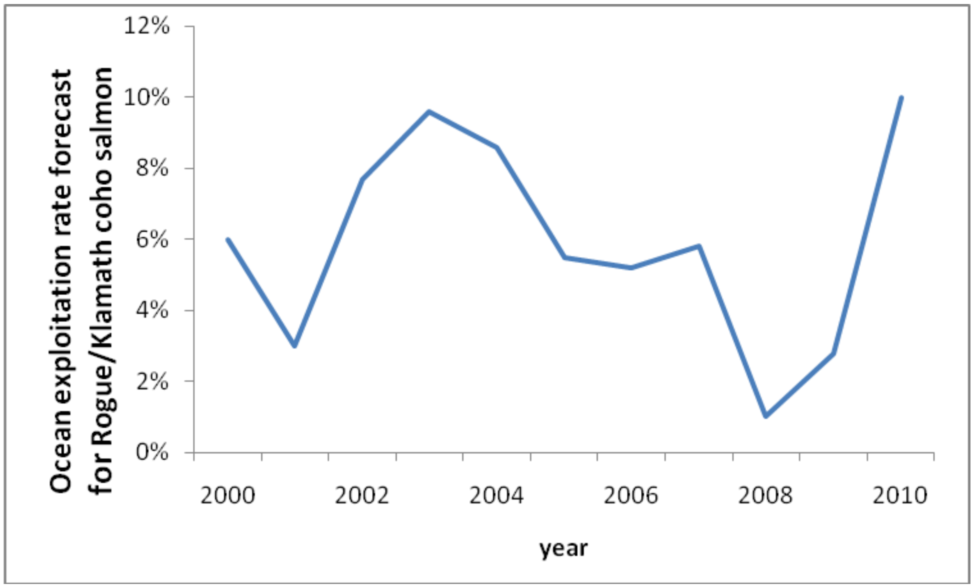


Figure 12.12. Rogue/Klamath (R/K) coho salmon ocean exploitation rate forecast for years 2000-2010 (PFMC 2010).

12.2.6.5 Small Population Size

SONCC coho salmon populations have declined significantly (e.g., Shasta River population) and are facing an additional threat from the effects of small population size. Many populations, such as the Shasta River population, are at a high risk of extinction because of their small population size (e.g., only 44, 62, and 115 spawners returned to the Shasta River in the 2010, 2011 and 2012 spawning seasons, respectively). With a majority of SONCC coho salmon populations at low abundance, random events become an increased and significant factor in the extinction process.

Small populations have a significantly increased risk of extinction (Shaffer 1981, McElhany et al. 2000, Fagan and Holmes 2006). In fact, time-to-extinction decreases logarithmically with decreasing population size (Lande 1993, Fagan and Holmes 2006). Population declines are likely to cause further declines, especially for small populations because stochastic factors exert more influence (Fagan and Holmes 2006). Small populations can be affected by different forms of stochastic pressure, not all of which affect large populations (Lande 1993). The fact that small populations can be affected by different forms of stochastic pressure results in extinction probabilities substantially greater than the extinction probabilities that would occur from a single form of stochasticity (Melbourne and Hastings 2008).

Small populations are likely largely influenced by random processes that affect population dynamics and population persistence. If the rate of population growth varies from one generation to the next, a series of generations in which there are successive declines in population size can lead to extinction of a small population even if the population is growing, on average, over a longer period.

Many SONCC coho salmon ESU populations have declined to such a low point that they are likely influenced by multiple, interacting processes (e.g., Shasta River, Middle Mainstem Eel River, Mainstem Eel River, Upper Mainstem Eel River, and Mattole River populations), that make recovery of the SONCC coho salmon ESU difficult. These random processes can create alterations in genetics, breeding structure, and population dynamics that may interfere with persistence of the species. Random processes can be expressed in four ways: genetic, demographic, environmental, and catastrophic events (Shaffer 1981, Lande 1993, McElhany et al. 2000, Reed et al. 2007).

Genetic stochasticity refers to changes in the genetic composition of a population unrelated to systematic forces (selection, inbreeding, or migration), i.e., genetic drift. Genetic stochasticity can have a large impact on the genetic structure of populations, both by reducing the amount of diversity retained within populations and by increasing the chance that deleterious recessive alleles may be expressed. The loss of diversity will likely limit a population's ability to respond adaptively to future environmental changes. In addition, the increased frequency with which deleterious recessive alleles are expressed (because of increased homozygosity) could reduce the viability and reproductive capacity of individuals.

Demographic stochasticity refers to the variability in population growth rates arising from random differences among individuals in survival and reproduction within a season. This variability will occur even if all individuals have the same expected ability to survive and reproduce and if the expected rates of survival and reproduction don't change from one generation to the next. Even though it will occur in all populations, demographic stochasticity is generally important only in populations that are already small (Lande 1993, McElhany et al. 2000). In very small populations, demographic stochasticity can lead to extinction (Shulenburger et al. 1999).

Environmental stochasticity is the type of variability in population growth rates that refers to variation in birth and death rates from one season to the next in response to weather, disease, competition, predation, or other factors external to the population (Melbourne and Hastings 2008). Catastrophic events are sudden, rare occurrences that severely reduce or eliminate an entire population in a relatively short period of time (McElhany et al. 2000). For example, the 1964 flood in northern California significantly degraded many watersheds and reduced the abundance of many SONCC coho salmon ESU populations.

These stochastic processes always occur; however, they don't always significantly influence population dynamics until populations are small. Due to the low abundance of most SONCC coho salmon ESU populations, stochastic pressure is likely to be one of the most significant threats to their persistence. Stochastic events have likely contributed to population instability and decline for many SONCC coho salmon ESU populations, which likely explain why recent adult returns remain low despite improved ocean conditions since 2007 and significant reductions in bycatch mortality from commercial and recreational fishery closures enacted more than 15 years ago.

12.3 Environmental Baseline of Coho Salmon in the Action Area

Endangered Species Act regulations define the environmental baseline as "…the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02). The "effects of the action" include the direct and indirect effects of the proposed action and interrelated or interdependent activities "…that will be added to the environmental baseline" (50 CFR 402.02). Implicit in both these definitions is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of ongoing Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to natural processes, are all part of the environmental baseline, to which effects of the proposed action are added for analysis.

This *Environmental Baseline* section is organized into two parts. First, NMFS describes the biological requirements and seasonal periodicity and life history traits of coho salmon within the action area. Next, NMFS describes the current extinction risk of all five populations in the Klamath River basin that are affected by the proposed action.

The Klamath River Basin covers approximately 1,531 square miles of the mainstem Klamath River and associated tributaries (excluding the Trinity, Salmon, Scott and Shasta River sub-basins) from the estuary to Link River Dam. Although anadromous fish passage is currently blocked at IGD, coho salmon once populated the basin at least to the vicinity of and including Spencer Creek at river mile (RM) 228 (Hamilton et al. 2005). Today, coho salmon occupy a small fraction of their historical area (NRC 2004) due to migration barriers and habitat degradation.

Coho salmon were once numerous and widespread within the Klamath River basin (Snyder 1931). However, the small populations that remain occupy limited habitat within tributary watersheds and the mainstem Klamath River below IGD (CDFG 2002a, NRC 2004). Coho salmon use varied freshwater habitat largely based upon life-stage and season (Sandercock 1991, Quinn 2005). However, habitat use can also be influenced by the quality of existing habitat and watershed function, factors which likely play a large role in coho salmon survival.

12.3.1 Periodicity of Coho Salmon in the Action Area

The biological requirements of SONCC ESU coho salmon in the action area vary depending on the life history stage present at any given time (Spence et al. 1996, Moyle 2002). In the action area for this consultation, the biological requirements for SONCC ESU coho salmon are the habitat characteristics that support successful adult spawning, embryonic incubation, emergence, juvenile rearing, migration and feeding. Generally, during salmonid spawning migrations, adult salmon prefer clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling (Sandercock 1991). Embryo survival and fry emergence depend on substrate conditions (e.g., gravel size, porosity, permeability, and dissolved oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 14 ºC or less (Quinn 2005). Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting (Moyle 2002). Migration of juveniles to rearing areas requires access to these habitats. Physical, chemical, and thermal conditions may all impede movements of adult or juvenile fish (Moyle 2002). This section outlines the life history traits and seasonal periodicities of coho salmon in the action area (Figure 12.13).

Figure 12.13. Life stage periodicities for coho salmon within the Klamath River Basin. Black areas represent peak use periods, those shaded gray indicate non-peak periods (Leidy and Leidy 1984, Moyle et al. 1995, USFWS 1998, NRC 2004, Justice 2007, Carter and Kirk 2008).

12.3.1.1 Adult migration and spawning

Adult coho salmon typically begin entering the lower Klamath River in late September (but as early as late August in some years), with peak migration occurring in mid-October (Ackerman et al. 2006). They move into the portion of the mainstem from IGD to Seiad Valley (RM 129) from the late fall through the end of December (USFWS 1998). Many returning adults seek out spawning habitat in sub-basins, such as the Scott, Shasta and Trinity rivers, as well as smaller mainstem tributaries throughout the basin with unimpeded access, functional riparian corridors and clean spawning gravel. Coho salmon generally migrate when water temperature is in the range of 7.2 ºC to 15.6 ºC, the minimum water depth is 18 cm, and the water velocity does not exceed 2.44 m/s (Sandercock 1991). However, coho salmon have been known to migrate at water temperatures up to 19 ºC in the Klamath River (Strange 2008). Coho salmon spawning within the Klamath River basin usually commences within a few weeks after arrival at the spawning grounds (NRC 2004) between November and January (Leidy and Leidy 1984).

Coho salmon spawning has been documented in low numbers and as early as November 15 within the mainstem Klamath River. From 2001 to 2005, Magneson and Gough (2006) documented a total of 38 coho salmon redds between IGD (RM 190) and the Indian Creek confluence (RM 109), although over two-thirds of the redds were found within 12 river miles of the dam. Many of these fish likely originated from the IGH. The amount of mainstem spawning habitat downstream of IGD has been reduced since construction of the dam because, for one thing, the introduction of spawning gravel from upstream sources has been interrupted.

12.3.1.2 Egg Incubation and Fry Emergence

Coho salmon eggs typically hatch within 8 to 12 weeks following fertilization, although colder water temperatures likely lengthen the process (Bjornn and Reiser 1991). Upon hatching, coho salmon alevin (newly hatched fish with yolk sac attached) remain within redds for another 4 to 10 weeks, further developing while subsisting off their yolk sac. Once most of the yolk sac is absorbed, the 30 to 35 millimeter fish (then termed "fry") begin emerging from the gravel in search of shallow stream margins for foraging and safety (NRC 2004). Within the Klamath River, fry begin emerging in mid-February and continue through mid-May (Leidy and Leidy 1984).

12.3.1.3 Juvenile Rearing

12.3.1.3.1 Fry

After emergence from spawning gravels within the mainstem Klamath River, or as they move from their natal streams into the river, coho salmon fry distribute themselves upstream and downstream while seeking favorable rearing habitat (Sandercock 1991). Further redistribution occurs following the first fall rain freshets as fish seek stream areas conducive to surviving high winter flows (Ackerman and Cramer 2006). They do not persist for long periods of time at water temperatures from 22 ºC to 25 ºC (Moyle 2002 and references therein) unless they have access to thermal refugia. Lethal temperatures range from 24 to 30 ºC (McCullough 1999), but coho salmon fry can survive at high daily maximum temperatures if (1) high quality food is abundant, (2) thermal refugia are available, and (3) competitors or predators are few (NRC 2004). Large woody debris and other instream cover are heavily utilized by coho salmon fry (Nielsen 1992, Hardy et al. 2006), indicating the importance for access to cover in coho salmon rearing.

12.3.1.3.2 Parr

As coho salmon fry grow larger (50-60 mm) they transform physically (developing vertical dark bands or "parr marks"), and behaviorally begin partitioning available instream habitat through aggressive agonistic interactions with other juvenile fish (Quinn 2005). These 50 to 60 mm fish are commonly referred to as "parr," and will remain at this stage until they migrate to the ocean. Typical parr rearing habitat consists of slow moving, complex pool habitat commonly found within small, heavily forested tributary streams (Moyle 2002, Quinn 2005). When rootwads, large woody debris, or other types of cover are present, growth is bolstered (Nielsen 1992), which increases survival. Water temperature requirements of parr are similar to that of fry.

Some coho salmon parr redistribute following the first fall rain freshets, when fish seek stream areas conducive to surviving high winter flows (Ackerman and Cramer 2006, Soto et al. 2008, Hillemeier et al. 2009). The Yurok Tribal Fisheries Program and the Karuk Tribal Fisheries Program have been monitoring juvenile coho salmon movement in the Klamath River using passive integrated transponder (PIT) tags. Some coho salmon parr, tagged by the Karuk Tribal Fisheries Program, have been recaptured in ponds and sloughs over 90 river miles away in the lower 6-7 miles of Klamath River. The PIT tagged fish appear to leave the locations where they were tagged in the fall or winter following initial fall freshets before migrating downstream in the Klamath River to off-channel ponds near the estuary where they are thought to remain and grow before emigrating as smolts the following spring (Voight 2008). Several of the parr (~65 mm) that were tagged at locations like Independence Creek (RM 95), were recaptured at the Big Bar trap (RM 51), which showed pulses of emigrating coho salmon during the months of November and December following rainstorms (Soto et al. 2008). Some PIT-tagged parr traveled from one stream and swam up another, making use of the mainstem Klamath during late summer cooling events. Summer cold fronts and thunderstorms can lower mainstem temperatures, making it possible for juvenile salmonids to move out of thermal refugia during cooling periods in the summer (Sutton et al. 2004)

Juvenile coho salmon (parr and smolts) have been observed residing within the mainstem Klamath River between IGD and Seiad Valley throughout the summer and early fall in thermal refugia during periods of high ambient water temperatures (>22 ºC). Mainstem refugia areas are often located near tributary confluences, where water temperatures are 2 to 6°C lower than the surrounding river environment (NRC 2004, Sutton et al. 2004). Habitat conditions of refugia zones are not always conducive for coho salmon because several thousand fish can be crowded into small areas, particularly during hatchery releases. Crowding leads to predator aggregation and increased competition, which triggers density dependent mechanisms.

Robust numbers of rearing coho salmon have been documented within Humbug (RM 171.5), Beaver (RM 163), Horse (RM 147.3) and Tom Martin Creeks (RM 143; Soto 2012), whereas juvenile coho salmon have not been documented, or are documented in very small numbers, using cold water refugia areas within the Middle and Lower Klamath Populations (Sutton et al. 2004). No coho salmon were observed within extensive cold-water refugia habitat adjacent to lower river tributaries such as Elk Creek (RM 107), Red Cap Creek (RM 53), and Blue Creek (RM 16) during past refugia studies (Sutton et al. 2004). However, Naman and Bowers (2007) captured 15 wild coho salmon ranging from 66 mm to 85 mm in the Klamath River between Pecwan and Blue creeks near cold water seeps and thermal refugia during June and July of 2007.

12.3.1.3.3 Juvenile outmigration

Migrating smolts are usually present within the mainstem Klamath River between February and the beginning of July, with April and May representing the peak migration months (Figure 12.14). Migration rate tends to increase as fish move downstream (Stutzer et al. 2006). Yet, some coho salmon smolts may stop migrating entirely for short periods of time if factors such as water temperature inhibit migration. Within the Klamath River, at least 11 percent of wild coho salmon smolts exhibited rearing-type behavior during their downstream migration (Stutzer et al. 2006). Salmonid smolts may further delay their downstream migration by residing in the lower river and/or estuary (Voight 2008). Sampling indicates coho salmon smolts are largely absent from the Klamath River estuary by July (NRC 2004).

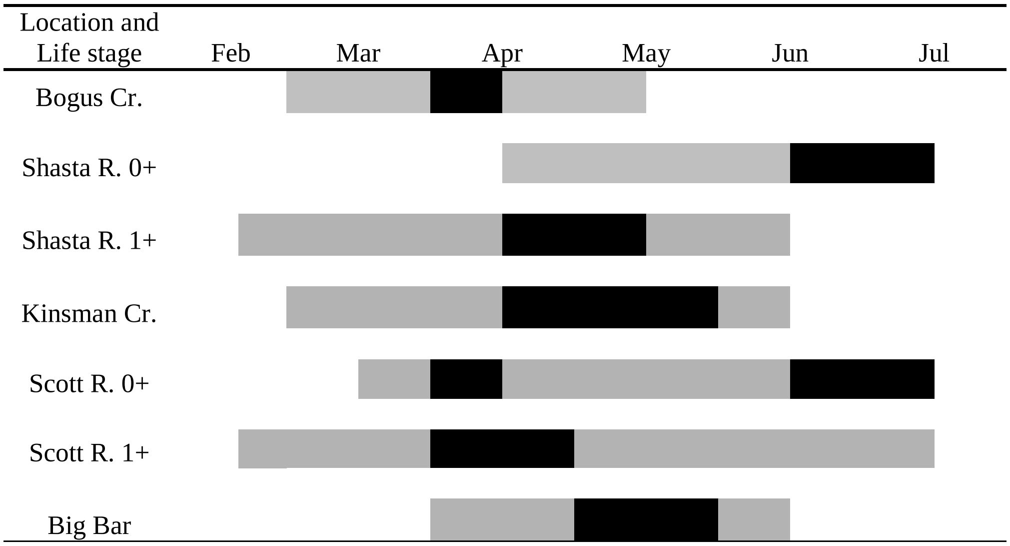


Figure 12.14. Juvenile coho salmon general emigration timing within the Klamath River and tributaries. Black areas represent peak migration periods, those shaded gray indicate non-peak periods (Pinnix et al. 2007, Daniels et al. 2011).

Peak emigration timing varies throughout the basin from April until July, depending on the watershed and the age class of fish moving (Pinnix et al. 2007). Many coho salmon parr migrate downstream from the Shasta River and into the mainstem Klamath River during the spring months after emergence and a brief (<3 month) rearing period in the Shasta River (Chesney et al. 2007). Water diversions and agricultural operations cause a loss of habitat (decrease in flow, increase in water temperature) in the Shasta River in the summer months and subsequent displacement of young of the year coho salmon from the Shasta River canyon (Chesney et al. 2007). In several different years, biologists from CDFW noticed a distinct emigration of 0+ (sub yearling) smolts around the week of May 21 on the Shasta River. Analysis of scale samples indicates that most of these fish are less than one year old (Chesney et al. 2007). Unlike the 0+ coho parr in the canyon that are leaving the Shasta River due to loss of habitat, these fish appear to be smolting.

The USGS and USFWS conducted studies aimed at estimating the survival of coho salmon smolts in the Klamath River. Between 2006 and 2009, the annual estimates of apparent survival of radio-tagged hatchery coho salmon from IGD to RM 20.5 ranged from 0.412 to 0.648 (Beeman et al. 2012). The current data and models indicate little support for a survival difference between hatchery and wild fish in 2006, but considerable model uncertainty exists (Beeman et al. 2007). Survival was lower in the reach from IGH to the Scott River than in reaches farther downstream (Beeman et al. 2012).

The variability of early life history behavior of coho salmon observed by Chesney et al. (2007) and by the Yurok and Karuk tribes mentioned in the sections above is not unprecedented; coho salmon have been shown to spend up to two years in freshwater (Bell and Duffy 2007), migrate to estuaries within a week of emerging from the gravels (Tschaplinski 1988), enter the ocean at less than one year of age at a length of 60 to 70 mm (Godfrey et al. 1975), and redistribute into riverine ponds following fall rains (Peterson 1982; Soto et al. 2008; Hillemeier et al. 2009). Taken together, the research by the Yurok and Karuk tribes, plus the research from outside the Klamath Basin, indicate that coho salmon in the Klamath River exhibit a diversity of early life history strategies, utilizing the mainstem Klamath River throughout various parts of the year as both a migration corridor and a rearing zone.

12.3.2 Risk of Extinction of Klamath Populations

While the *Status of the Species* section discussed the viability of the SONCC coho salmon ESU, this section provides a more in-depth discussion of the extinction risk of the Klamath River basin populations affected by the proposed action, which consist of the Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon River populations.

Within the California portion of the SONCC coho salmon ESU, estimating the risk of extinction of a given coho salmon population is difficult since longstanding monitoring and abundance trends are largely unavailable. Williams et al. (2008) proposed biological viability criteria, including population abundance thresholds. The viability criteria developed by Williams et al. (2008) address and incorporate the underlying viability concepts (i.e., abundance, productivity, diversity and spatial structure) outlined within McElhany et al. (2000), and are intended to provide a means by which population and ESU viability can be evaluated in the future when more population data become available. Comparing population estimates against population viability thresholds proposed by Williams et al. (2008) allow NMFS to make conservative assumptions concerning the current risk of extinction of Klamath River mainstem and tributary populations.

Generally speaking, none of the five populations of coho salmon affected by the proposed action are considered viable. Even the most optimistic estimates from Ackerman et al. (2006) indicate each population falls well short of abundance thresholds for the proposed viability criteria that, if met, would suggest that the populations were at low risk of extinction for this specific criterion. In some years, populations have fallen below the high risk abundance threshold, such as the Shasta River population. A population is considered at low risk of extinction if all criteria are met, therefore failure to meet any one specific criterion would result in the population being at an elevated risk of extinction (*i.e.*, not viable). The annual adult run size estimate between 2009 and 2012 has been fewer than 116, with a low of nine adults for the Shasta River, all of which were males. Similarly, the Scott River coho salmon population fell well below the high risk abundance threshold in three of the most recent four years (Table 12.3). For both of these populations, abundance is low and they are likely experiencing depensation pressures. With regard to spatial structure and diversity, Williams et al. (2008) abundance thresholds were based upon estimated historical distribution and abundance of spawning coho salmon, and thus capture the essence of these two viability parameters. By not meeting the low risk annual abundance threshold, all Klamath River coho salmon populations are likewise failing to meet spatial structure and diversity conditions consistent with viable populations. Several of these populations have also recently failed to meet the high risk abundance thresholds, underscoring the critical nature of recent low adult returns.

Below, the populations that may be affected by the proposed action are discussed in more detail. Run size approximations compiled by CDFW were used to gage whether specific populations had met the low extinction risk threshold at any time during the period 2009 to 2012 (Table 12.3). Populations in the Shasta, Scott, and Salmon rivers do not spawn in the action area, but use the action area for migration, rearing, and holding. Effects of the proposed action, such as hydrologic changes, are the highest in the reach between IGD and Orleans. Therefore, the Upper Klamath, Shasta and Scott River populations are affected by the proposed action to a greater degree than other populations located downstream.

Table 12.3. Estimated naturally spawning coho salmon abundance for populations in the action area.

Stratum	Population	2009	2010	2011	2012	High Risk Annual Abundance Threshold[a]	Low Risk Annual Abundance Threshold[b]
Interior – Klamath River	Upper Klamath [d]	< 200	<350	<300	<300	425	8,500
	Middle Klamath [c]	< 1,500	< 1,500	< 1,500	<1,500	113	3,900
	Shasta River [e]	9	44	65	115	531	8,700
	Scott River [e]	81	911	344	201	441	8,800
	Salmon River [f]	< 50	< 50	< 50	< 50	115	4,000

[a] High risk annual abundance level corresponds to a population threshold below which there exists a high risk of depensation (*i.e.,* decreasing productivity with decreasing density). Depensatory processes at low population abundance result in high extinction risks for very small populations because any decline in abundance further reduces the population's average productivity, resulting in a steep slide toward extinction (McElhany et al. 2000).
[b] Low risk annual abundance level represents the minimum number of spawners required for a population to be considered at low risk. These thresholds are modified from Williams et al. 2008, and are in NMFS 2012a.
[c] Using the highest estimates (i.e., 2004) from Ackerman et al. 2006, these estimates for 2008 to 2010 are generous since abundance throughout most of the SONCC coho salmon ESU range have declined significantly since 2004.
[d] Estimates based on Bogus Creek counts (Knechtle and Chesney 2011, Knechtle 2013) plus small numbers of mainstem and tributary spawners (Corum 2011).
[e] Estimate from Chesney and Knechtle (2011a and 2011b) and Knechtle (2013).
[f] Continues from Ackerman et al's (2006) estimates for the Salmon River.

12.3.2.1 Upper Klamath River Population

The Upper Klamath River population covers the Klamath River and tributaries from upstream of Portuguese Creek past IGD to Spencer Creek (inclusive), the historical upstream distribution of coho salmon in the Klamath Basin (Hamilton et al. 2005). Using a variety of methods, including data from a video weir on Bogus Creek, maps, and an intrinsic potential (IP) database, Ackerman et al. (2006) developed run size approximations for tributaries in this stretch of river for years

2001 to 2004. Using reports from USFWS, Ackerman et al. also assumed that spawning in the mainstem was limited to 100 fish or fewer.

Using similar data and assumptions as Ackerman et al. (2006), NMFS estimates the numbers of adult spawners returning to the Upper Klamath River Population in 2009 to 2012 are below the low risk abundance threshold of 8,500 (Table 12.3). Although the count of coho salmon on Bogus Creek was probably not complete in 2009, seven coho salmon were observed. In 2010, a total of 154 adults returned to Bogus Creek, although approximately 28 percent were hatchery-origin fish. Preliminary estimates show that 134 adult coho salmon, 33 percent of which were hatchery-origin fish, returned to Bogus Creek in 2011. Using Bogus Creek as an indicator of the abundance and percentage of hatchery origin spawners, the Upper Klamath River Population has a high risk of extinction.

Coho salmon are currently spatially restricted to habitat below IGD. Coho salmon in this population spawn and rear primarily in several of the larger tributaries between Portuguese Creek and IGD, namely Bogus, Horse, Beaver, and Seiad creeks. Spawning surveys also give an indication of the population size and productivity. Spawning has been documented in low numbers within the mainstem Klamath River. From 2001 to 2005, Magneson and Gough (2006) documented a total of 38 coho salmon redds between IGD (RM 190) and the Portuguese Creek confluence (RM 109), although over two-thirds of the redds were found within 12 river miles of the dam. Many of these fish likely originated from IGH. A population of coho salmon parr and smolts rear within the mainstem Klamath River by using thermal refugia near tributary confluences to survive the high water temperatures and poor water quality common to the Klamath River during summer months.

Little is known about the genetic and life history diversity of the upper Klamath River Population Unit. However, the population is believed to be highly influenced by IGH (Garza 2012 *in* CDFG 2012) and has likely experienced a loss of life history diversity due to environmental conditions and loss of habitat. Currently, genetic work is continuing to be performed to determine the genetic makeup of wild and hatchery fish from the Upper Klamath Population Unit. The Upper Klamath River coho salmon population is at a high risk of extinction because its abundance, spatial structure and diversity are substantially limited compared to historical conditions.

12.3.2.2 Middle Klamath River Population

The Middle Klamath River Population covers the area from the Trinity River confluence upstream to Portuguese Creek (inclusive) and Seiad and Grider Creeks. Little data on adult coho are available for this stretch of river (Ackerman et al. 2006). Adult spawning surveys and snorkel surveys have been conducted by the US Forest Service and Karuk Tribe, but data from those efforts are insufficient to draw definitive conclusions on run sizes (Ackerman et al. 2006). Ackerman et al. (2006) relied on professional judgment of local biologists to determine what run sizes would be in high, moderate, and low return years to these tributaries; therefore, the run size approximations are judgment based estimates. In each of the three most recent years, the run size estimates fall below the low risk annual abundance threshold, but are above the high risk abundance threshold (Table 12.3). Therefore, the Middle Klamath River Population has a moderate risk of extinction.

Most of the juveniles observed in the Middle Klamath have been in the lower parts of the tributaries, which suggest many of these fish are non-natal rearing in these refugial areas. Adults and juveniles appear to be well distributed throughout the Middle Klamath; however use of some spawning and rearing areas is restricted by water quality, flow, and sediment issues. Although its spatial distribution appears to be good, many of the Middle Klamath tributaries are used for non-natal rearing, and too little is known to infer its extinction risk based on spatial structure. Diversity of this population appears to be adequate and IGH coho salmon are not known to stray into tributaries associated with this population.

12.3.2.3 Shasta River Population

Due to its proximity to the IGH, the Shasta River likely has a high hatchery coho salmon stray rate, probably surpassed in the Klamath River only by Bogus Creek. The average percentage of hatchery origin coho salmon entering the Shasta River in 2008, 2009, and 2010 was 73, 20, and 25 percent, respectively with adult coho salmon returns of 30, 9, and 44 in 2008, 2009, and 2010 respectively (Chesney and Knechtle 2011a). CDFW estimates that 62 and 138 adult coho salmon returned in the Shasta River in 2011 and 2012 (Knechtle 2013). These numbers are well below the high risk abundance threshold (Table 12.3). At these low levels, depensation or Allee effects (e.g., failure to find mates), inbreeding and genetic drift, which accelerate the extinction process, become a concern. Therefore, the Shasta River Population has a high risk of extinction, and has substantial genetic and other depensation risks associated with low numbers of adult spawners.

The current distribution of spawners is limited to the Shasta River Canyon, mainstem Shasta River from river mile 17 to river mile 23, lower Parks Creek, lower Yreka Creek, and the upper Little Shasta River. In addition to Big Springs, juvenile rearing is also generally confined to these same areas, especially in the summer. Because of this limited distribution, the Shasta River coho salmon population is at high risk of extinction because its spatial structure and diversity are very limited compared to historical conditions.

12.3.2.4 Scott River Population

Ackerman et al. (2006) estimated the range of adult abundance for the Scott River coho salmon population and approximated the total run size as 1,000 to 4,000 for 2001, 10 to 50 for 2002 and 2003, and to 2,000 to 3,000 for 2004. Variable rates of effort and differences in survey conditions between years may have influenced these estimates of run size. Uncertainty regarding mainstem spawning of coho in the Scott River was also a source of concern (Ackerman et al. 2006). Since 2007, a video weir was placed in the Scott River, alleviating concerns about data collection methods. In 2008 and 2009, 63 and 81 adult coho salmon returned to the river, respectively. CDFW estimates that 344 and 191 adult coho salmon returned in the Scott River in 2011 and 2012, respectively (Knechtle 2013). These abundances are well below the high risk abundance threshold (Table 12.3). The adult return in 2010 was 911, which exceeds the high risk abundance level but is below the low risk level. Although one of the year classes exceeds the high risk depensation level, the average abundance of the past three years is slightly greater than the high risk abundance threshold. Therefore, the Scott River Population currently has a moderate risk of extinction.

Fish surveys of the Scott River and its tributaries have been occurring since 2001. These surveys have documented coho salmon presence in 11 tributaries, with the six most productive of these tributaries consistently sustaining rearing coho salmon juveniles in limited areas. The five other tributaries do not consistently sustain juvenile coho salmon, indicating that the spatial structure of this population is restricted by available rearing habitat. The spatial structure of this population appears restricted. The diversity of this population has not been studied.

12.3.2.5 Salmon River

Surveys suggest that specific spawning areas are re-visited each year and that fish in certain spawning areas may have specific life history traits, such as different run timing (Pennington 2009). Based on the low hatchery influence and small population size, the genetic structure of this population likely retains much of its wild character, but overall the level of natural genetic diversity has likely declined.

With limited data, Ackerman et al. (2006) estimated fewer than 50 spawners for the Salmon River coho salmon population for 2001, 2002 and 2003. Since 2002, the Salmon River Restoration Council along with CDFW, the Karuk Tribe, the USFS and the USFWS have conducted spawning and juvenile surveys throughout the watershed. Annual adult coho salmon abundance surveyed in the Salmon River has varied between 0 and 14 spawning adults since 2002 (Salmon River Restoration Council 2006, 2010). Between 2002 and 2007 only 18 adults and 12 redds (average of 4 spawners per year) were found in the 25 km of surveyed habitat. Without any new information to show coho salmon spawner abundance increased, NMFS continues to estimate the total Salmon River spawner abundance as less than 50 individuals, which is well below the depensation threshold. An adult population of 50 or less would represent a population with limited spatial structure. Based on the estimated spawning abundance and likely limited spatial structure, the Salmon River coho salmon population is at high risk of extinction (Table 12.3).

12.3.3 Factors Affecting Coho Salmon in the Action Area

In addition to the habitat conditions and the factors affecting the SONCC coho salmon ESU critical habitat in the action area that are described in the *Environmental Baseline of Coho Salmon Critical Habitat in the Action Area* section, hatcheries, fish harvest, pinniped predation, and activities that have incidental take permits or exemptions also affect the current status of SONCC ESU coho salmon in the action area.

12.3.3.1 Hatcheries

Two fish hatcheries operate in the Klamath River basin, the Trinity River Hatchery near the town of Lewiston and the IGH on the mainstem Klamath River near Hornbrook, California. Both hatcheries mitigate for anadromous fish habitat lost as a result of the construction of dams on the mainstem Klamath and Trinity rivers, and production focuses on Chinook and coho salmon, and steelhead. The Trinity River Hatchery annually releases approximately 4.3 million Chinook salmon, 0.5 million coho salmon and 0.8 million steelhead. The IGH annually releases approximately 6.0 million Chinook salmon, 75,000 coho salmon and 200,000 steelhead. Together, these two hatcheries annually release a total of approximately 11,875,000 hatchery salmonids into the Klamath Basin.

Of the 6 million Chinook salmon that are released from the IGH, about 5.1 million are released as smolts from mid-May through early June and about 900,000 are released as yearlings from mid-October through November. The 75,000 coho salmon and the 200,000 steelhead trout are released as yearlings after March 15th each spring. Prior to 2001, all of the Chinook salmon smolts were released after June 1 of each year. However, beginning in 2001, the CDFW began implementing an early release strategy in response to recommendations provided by the Joint Hatchery Review Committee (CDFG and NMFS 2001). The Joint Hatchery Review Committee stated that the current smolt release times (June 1 to June 15) often coincides with a reduction in the flow of water released by Reclamation into the Klamath River, and that this reduction in flows also coincides with a deterioration of water quality and reduces the rearing and migration habitat available for both natural and hatchery reared fish. In response to these concerns the CDFW proposed an Early Release Strategy and Cooperative Monitoring Program in April of 2001 (CDFG 2001). The goals of implementing the early release strategy are to:

1. Improve the survival of hatchery released fall Chinook salmon smolts from IGH to the commercial, tribal, and sport fisheries.

2. Reduce the potential for competition between hatchery and natural salmonid populations for habitats in the Klamath River, particularly for limited cold water refugia habitat downstream of IGD.

As a result, the release strategy was modified to allow for proportionate releases of Chinook salmon smolts to occur earlier in May provided these smolts reach a size of about 90 fish/lbs. Although these management strategies are intended to reduce impacts to wild salmonids, some negative interactions between hatchery and wild populations likely still persist through competition between hatchery and natural fish for food and resources, especially limited space and resources in thermal refugia important during summer months (McMichael et al. 1997, Fleming et al. 2000, Kostow et al. 2003, Kostow and Zhou 2006). The peak emigration timing of coho salmon yearlings produced in the Shasta River occur during the month of April which is consistent with release timing of coho salmon and steelhead trout yearlings from IGH, but is well before the release timing of hatchery produced Chinook salmon smolts from IGH (Daniels et al. 2011). Emigration of coho salmon yearlings from the Scott River has been shown to occur over a much longer period of time with peak emigration numbers occurring anytime between March and early June (Daniels et al. 2011).

The exact effects on juvenile coho salmon from competition and displacement in the Klamath River from the annual release of 5,000,000 hatchery-reared Chinook salmon smolts from IGH are not known and likely vary between years depending on hydrologic and habitat conditions present. The hatchery releases of yearling coho salmon (75,000 fish) and steelhead trout

(200,000) are much smaller in number and although there are likely to be some adverse competitive interactions that occur between these groups, other factors related to disease and the poor condition of habitats in the major tributary streams likely have a greater impact on survival of wild coho salmon. Modeling conducted for CDFW's IGH HGMP indicates that the release of 75,000 coho salmon juveniles has the potential to reduce natural coho salmon juvenile abundance by up to 6 percent through increased predation, competition and disease, assuming the natural juvenile coho salmon abundance is 75,000 (CDFG 2012). The impact is lower if natural population abundance is greater than 75,000 and higher if the natural abundance is lower than 75,000 (CDFG 2012).

A Draft HGMP has been developed for IGH as part of the CDFW's application for an ESA section 11(a)(1)(A) permit for hatchery operation (CDFG 2012; 78 FR 1200, January 8, 2012; 78 FR 6298, January 30, 2013). The HGMP is intended to guide hatchery practices toward the conservation and recovery of listed species, specifically, the upper Klamath River coho population. Although the HGMP has yet to be approved, the CDFW began implementing in 2010 some of the recommended changes to the management of IGH coho salmon, including the use of a genetic parental based spawning matrix to reduce potential inbreeding and improve fitness over time (Chesney and Knechtle 2011c).

In a review of 270 references on ecological effects of hatchery salmonids on natural salmonids, Flagg et al. (2000) found that, except in situations of low wild fish density, increasing release numbers of hatchery fish can negatively affect naturally produced fish. Also evident from the review is that competition of hatchery fish with naturally produced fish almost always has the potential to displace wild fish from portions of their habitat (Flagg et al. 2000). The increase in density of juvenile salmonids, combined with the reduction in instream habitat resulting from decreased flows in June resulting from hydrologic alteration of the Klamath River (see Hydrologic Alteration section above), are likely to have negative impacts on coho salmon juveniles. During the summer, sometimes hundreds or even thousands of juvenile salmonids can be forced by water temperatures into small areas with cold water influence (Sutton et al. 2007).

Another important consideration in regards to SONCC coho salmon ESU diversity, spatial structure, and productivity is how smaller coho salmon populations from tributaries such as the Scott and Shasta rivers, which are important components of the ESU viability, are affected by straying of hatchery fish. The average annual percentage of hatchery coho salmon in the Shasta River from 2001 to 2010 was 23, with a high of 73 in 2008 (Chesney and Knechtle 2011a, Ackerman et al. 2006). These data indicate that a fair amount of straying of IGH fish occurs into important tributaries of the Klamath River, like the Shasta River, which has the potential to reduce the reproductive success of the natural population (Chilcote 2003, Mclean et al. 2003, Araki et al. 2007, Chilcote et al. 2011) and negatively affect the diversity of the interior Klamath populations via outbreeding depression (Reisenbichler and Rubin 1999, HSRG 2004). However, recent preliminary findings by NMFS Southwest Fisheries Science Center suggest that hatchery and wild fish have already interbred in the Klamath basin, and a pure wild stock no longer exists (CDFG 2012). The total impacts of hatchery strays on Klamath River populations are not well understood. However, known straying data and preliminary genetic typing indicate that hatchery releases have negatively impacted wild populations, particularly in the upper basin.

Although there are risks to Klamath coho salmon populations from continued releases of coho smolts from the IGH, due to the significantly depressed status of the Upper Klamath, Scott, and Shasta populations, releases of coho salmon could continue to contribute towards coho salmon abundance, one of the VSP criteria (NMFS 2010a). However, negative effects still occur potentially increasing over time due to climate change. For example, freshwater habitat availability for juvenile coho salmon rearing and migration is expected to decrease in the future due to climate warming (Mote et al. 2003, Battin et al. 2007); therefore, competition for limited thermal refuge areas will increase. Bartholow (2005) found a warming trend of 0.5 °C/decade in the Klamath River and a decrease in average length of river with temperatures below 15°C (8.2 km/decade), underscoring the importance of thermal refugia areas. However, hatchery releases are expected to remain constant during this period of shrinking freshwater habitat availability, which makes the detrimental impact from density-dependent mechanisms in the freshwater environment to naturally produced coho salmon populations increase through time under a climate warming scenario. In this way, hatcheries likely impact the effective use of habitats by wild coho salmon in the future if shared use of these habitats by wild and hatchery stocks begin to exceed capacity limitations and food supplies.

Behrenfeld et al. (2006) found that ocean productivity is closely coupled to climate variability. A transition to a warmer climate and sea surface may be accompanied by reductions in ocean productivity, which affects fisheries (Beamish and Mahnken 2001, Ware and Thomson 2005, Behrenfeld et al. 2006). The link between total mortality and climate could be operating via the availability of nutrients regulating the food supply and hence competition for food (i.e. bottom–up regulation) in the ocean (Beamish and Mahnken 2001, Ware and Thomson 2005). Hatchery releases may exacerbate the effect of reductions in ocean productivity on naturally produced salmonids through density-dependent mechanisms, which have their strongest effect during the first year of salmonid life in the ocean (Beamish and Mahnken 2001), because hatchery releases are rarely reduced during years of poor ocean productivity (Beamish et al. 1997, Levin et al. 2001, Sweeting et al. 2003). These competitive effects may negatively affect the population abundance and productivity of the interior Klamath populations.

12.3.3.2 Fish Harvest

Coho salmon have been harvested in the past in both coho- and Chinook-directed ocean fisheries off the coasts of California and Oregon. More stringent management measures that began to be introduced in the late 1980s have reduced coho salmon harvest substantially. Initial restrictions in ocean harvest were due to changes in the allocation of Klamath River fall-run Chinook salmon (KRFC) between tribal and non-tribal fisheries. These restrictions focused on the Klamath Management Zone where the highest KRFC impacts were observed (Good et al. 2005). The prohibition of coho salmon retention was expanded to include all California waters in 1995 (Good et al. 2005). With the exception of some harvest by the Yurok, Hoopa Valley and Karuk tribes for subsistence, ceremonial and commercial purposes[9], the retention of coho salmon is also

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[9] Coho salmon harvest by the Yurok Tribe ranged from 25 to 2,452 adults between 1992 and 2009 (Williams 2010). Except for three years, the majority of the tribal catch (58-79 percent) between 1997 and 2009 comprised of hatchery fish (Williams 2010). An average of approximately 60 percent of the annual number of harvested coho salmon between 1997 and 2009 were hatchery fish.

prohibited in California river fisheries. In order to comply with the SONCC coho salmon ESU conservation objective, projected incidental mortality rates on Rogue/Klamath River hatchery coho salmon stocks are calculated during the preseason planning process using the coho salmon FRAM (Kope 2005). Season options are then crafted that satisfy the 13 percent maximum ocean exploitation rate. In recent years, these rates have been well below 13 percent with 5 of the last 8 years at or below 6 percent and no year exceeding 9.6 percent. Preliminary post-season estimates of ocean incidental mortality rates for 2010 and 2011 are 2.2 and 3.8 percent, respectively (PFMC 2011, 2012). Due to the predicted low abundance of Sacramento River Basin fall-run Chinook salmon, severe ocean salmon fishing closures were adopted in 2008. Tribal and other harvest effects are expected to continue.

Because incidental ocean exploitation and tribal harvest rates vary, the effects of salmon harvesting to the VSP parameters of the Klamath populations may vary from neutral to negative. The main effect to the VSP parameters is a reduction in the population abundance level. However, by selecting for certain size classes, runs, or certain ages of individuals, harvesting can also impact genetic diversity. By reducing the number of adults returning to a stream or river, fish harvesting can in turn reduce the amount of marine derived nutrients, which can impact summer and winter juvenile rearing areas by limiting the amount of food available to juveniles as invertebrate production may suffer.

12.3.3.3 Pinniped Predation

Pinniped predation on adult salmon can significantly affect escapement numbers within the Klamath River basin. Hillemeier (1999) assessed pinniped predation rates within the Klamath River estuary during August, September, and October 1997, and estimated that a total of 223 adult coho salmon were consumed by seals and sea-lions during the entire study period. Fall-run Chinook salmon were the main fish consumed (an estimated 8,809 during the entire study period), which may be primarily due to the fall-run Chinook salmon migration peaking during the study period (the peak of the coho salmon run is typically October through mid-November). Hillemeier (1999) cautioned that the predation results may represent unnaturally high predation rates, since ocean productivity was comparatively poor during the El Niño year of 1997. The Marine Mammal Protection Act of 1972, as amended, protected seals and sea lions from human harvest or take, and as a result, populations are now likely at historical highs (Low 1991). Similarly to harvesting, reductions in the amount of marine derived nutrients in a stream can result from predation, which reduces the amount of food available to winter and summer rearing juveniles.

12.3.3.4 Recent activities that have permitted or exempted take in the action area

Some of the activities listed above have either permitted or exempted take of coho salmon in the action area. A summary of projects that have current exemption or permit to take SONCC ESU coho salmon in the action area is provided below (Table 12.4). Note that the effects of the Klamath Project Operations and PacifiCorp HCP were discussed earlier, and that the effects of the Klamath Project as described in the 2010 BiOp (NMFS 2010a) will be replaced by this BiOp. The other activities where NMFS permitted or exempted take in the action area are associated with habitat restoration and research/monitoring. Habitat restoration, research, and monitoring activities are generally beneficial for the species, and have resulted in less injury or mortality than permitted or exempted.

Table 12.4. List of projects or activities that currently have permitted or exempted take of coho salmon in the action area.

Project/Activity	Duration	Action Agency	Estimated Number or Extent of Take Exempted/Permitted
Klamath Project Operations	2010-2018	Reclamation	Habitat surrogate (i.e., proportional loss of habitat availability identified in Table 19 of NMFS 2010a and decreased smolt/flow transit time identified in Table 20 in NMFS 2010a)
Yurok Tribe's eulachon survey	2011-2013	NMFS	Up to 60 coho salmon juveniles/yr
Habitat restoration	2012-2017	NOAA Restoration Center	Up to 766* juvenile coho salmon may be annually captured, of which up to 0.6 percent of the captured coho salmon may be injured each year, and up to 0.6 percent of the captured coho salmon will be killed each year.
Regional general permit for CDFW's Fisheries Restoration Grant Program	2010-2015	Corps of Engineers	Injury or mortality of juveniles limited to 3 percent of captured individuals and no more than 2 to 12 instream projects per HUC 10 watershed size per year.
PacifiCorp habitat conservation plan	2012-2022	PacifiCorp	Habitat surrogate (i.e., habitat will be available consistent with Table 19 of the Klamath Project Operations BiOp; estimated smolt travel times will be consistent with Table 20 of the 2010 Klamath Project Operations BiOp; low dissolved oxygen concentration [<85 percent saturation up to 7 consecutive days] in the six mile reach below IGD between June 15 and September 30; increased mean weekly minimum water temperatures below IGD of up to 4 °C during June 15 and September 1)
Juvenile monitoring on the mainstem Klamath River	2005-2013	FWS	Up to 74,398 juveniles may be captured annually, of which up to 3.0 percent may be killed. Up to 100 adults may be annually captured, of which up to 2.0 percent may be killed.
Research	2012-2017	CDFW	Up to 1000** natural origin adults and up to 2,000 hatchery adults may be captured. No more than 1.5 percent of the captured adult may be killed. Up to 20,000* natural origin smolts and up to 5,000 hatchery smolts may be captured. No more than 2 percent of captured smolts may be killed. Up to 80,000* natural origin juveniles and up to 5,000 hatchery juveniles may be captured. No more than 3.0 percent of captured juveniles may be killed.
*Take numbers represent total for Humboldt, Del Norte, Trinity, Siskiyou, and a part of Mendocino counties **Take numbers represent entire ESU in CA.			

12.4 Effects to Individuals

The proposed action affects SONCC coho salmon through the Project Operations and the annual restoration funding of approximately $500,000. Project Operations affect coho salmon through hydrologic and habitat modifications in the mainstem Klamath River, while the annual restoration funding affects coho salmon during restoration implementation and through habitat improvements. Note that the use of the term “proposed action” in the *Project Operations* section represents Klamath Project operations component of the proposed action, while the use of the term “proposed action” in the *Restoration Activities* section represents the habitat restoration component of the proposed action.

12.4.1 Project Operations

As stated in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section, the coho salmon effects analysis is based on the results of the formulaic approach described in the proposed action and on one element of the proposed adaptive management where details are sufficient for analysis. Besides the proposed near real-time management for minimizing disease risks, the coho salmon effects analysis does not include the proposed adaptive management because NMFS does not have sufficient information on the adaptive management approach at this time. Under the proposed action, the median Project delivery from all sources by water year is 428,200 acre-ft with a minimum of 178,000 acre-ft and a maximum of 477,000 acre-ft (Reclamation 2012). Approximately 80 percent of the Project water delivery is not returned to the mainstem Klamath River (Cameron 2013). Therefore, approximately 20 percent of the Project water is returned to the Klamath River as agricultural tailwater, which contributes to impaired water quality in the Klamath River. The proposed action’s effects to coho salmon result from the reduction to flows at IGD.

12.4.1.1 Exposure

As previously discussed in the *Hydrologic Effects* section (i.e., section 11.4.1.1), the proposed action reduces flows in the mainstem Klamath River throughout most of the year. Therefore, all life stages of coho salmon are expected to be exposed to proposed action effects in the next ten years (Table 12.5). However, different populations of coho salmon will be exposed to varying levels of flow effects under the proposed action. Populations proximal to IGD will experience the most pronounced exposure, while populations farthest away, such as the Lower Klamath River population, are not likely to be exposed.

Adult coho salmon are present in the mainstem Klamath River only during the upstream migration and spawning period. Upstream migration of adult coho salmon in the Klamath River spans the period from September to January, with peak movement occurring between late-October and mid-November. In most years, all adults are observed in tributaries prior to December 15, while in some years (e.g., Scott River in 2009) most adults are observed between December 15 and January 1. Therefore, adults that spawn in tributaries are expected to be exposed primarily in the late fall to early winter.

A small number of coho salmon (e.g., fewer than approximately 50 each year) spawn in the mainstem Klamath River, and thus a relatively small number of embryos and fry are expected to be present in the mainstem each winter and spring. In addition, coho salmon fry from tributaries emigrate into the mainstem Klamath River as a result of ecological conditions (e.g., high flow displacement or deleterious tributary conditions [Chesney et al. 2007]) or behavioral tendencies. However, most coho salmon fry from the tributaries (i.e., ≥ 50 percent) are assumed to rear in the tributaries.

Juveniles likely rear in the mainstem throughout the year, and consist of parr and smolts. Juvenile coho salmon have been observed residing within the mainstem Klamath River downstream of Shasta River throughout the summer and early fall in thermal refugia during periods of high water temperatures (>22 °C). Coho salmon parr may be present in the mainstem from the time they leave the tributaries to the following winter. However, most parr from the tributaries (i.e., ≥ 50 percent) are assumed to rear in the tributaries.

Coho salmon smolts are expected to migrate to the mainstem Klamath River beginning in late February, with most natural origin smolts outmigrate to the mainstem during March, April and May (Wallace 2004). Courter et al. (2008), using USFWS and CDFW migrant trapping data from 1997 to 2006 in tributaries upstream of and including Seiad Creek (e.g., Horse Creek, Shasta River, and Scott River), reported that 56 percent of coho smolts were trapped from April 1 through the end of June.

Once in the mainstem, smolts move downstream fairly quickly, with estimated median migration rates of 13.5 miles/day (range -0.09 to 114 miles/day) for wild coho salmon and 14.6 miles/day (range -2.3 to 27.8 miles/day) for hatchery coho salmon (Stutzer et al. 2006). Beeman et al. (2012) found that wild coho salmon smolts released near IGD had a median travel time of 10.4 and 28.7 days in 2006 and 2009, respectively, to the estuary. The maximum recorded time of wild coho salmon smolts traveling on the mainstem from IGD to the estuary was 63.8 days (Beeman et al. 2012).

Table 12.5. A summary of the coho salmon life stage exposure period to project-related flow effects.

Life Stage	Coho Salmon Population(s)	General Period of exposure when individuals are in the mainstem
Adults	Upper Klamath River	September to mid-January
Embryos to pre-emergent fry	Upper Klamath River	November to mid-March
Fry	Upper Klamath, Shasta River, Scott, and Middle Klamath rivers	March to mid-June
Juvenile (parr)	Upper Klamath, Shasta River, Scott, and Middle Klamath rivers	May to February
Juvenile (smolts)		March to June

12.4.1.2 Response

12.4.1.2.1 Adults

Minimum daily average flows under the proposed action are at least 950 cfs during the period of upstream migration. Reclamation (2012) determined that the proposed action is unlikely to have an appreciable impact on the mainstem migration of adult coho salmon from low flow blockage. Reclamation made their determination by comparing the number of days the proposed action will result in IGD flows below 1,000 cfs in the fall to those observed in the POR. Flows less than 1,000 cfs may hinder adult salmon migration into the tributaries (Reclamation 2012). Even though the proposed action will result in more days in the fall than the observed POR when flows are less than 1000 cfs, Reclamation determined that the hydrologic conditions under the proposed action will likely support adequate adult passage.

While NMFS does not agree with Reclamation's use of the observed POR as a metric to represent adequate migration, NMFS concurs with Reclamation's determination that the proposed action is not likely to adversely affect adult coho salmon migration in the mainstem Klamath River. Coho salmon escapement monitoring have confirmed successful adult passage in the mainstem Klamath River when IGD releases were at least 950 cfs in the fall (e.g., FWS mainstem redd/carcass surveys, CDFW Shasta and Bogus Creek video weir studies, IGH returns). The apparent lack of coho salmon migration delays resulting from past IGD flows of at least 950 cfs is consistent with studies reviewed by Jonsson (1991) that suggest low flows are less likely to delay adult fish migration in large rivers, such as the mainstem Klamath River. In addition, water temperature in the mainstem Klamath River are cool or cold in the late fall and winter, and is not expected to impede coho salmon adult migration. In addition, flow variability incorporated into the proposed action will likely provide an environmental cue to stimulate adult coho salmon upstream migration when flows in the mainstem Klamath River mimics natural fall and winter freshets.

12.4.1.2.2 Eggs

As discussed in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section and assuming coho salmon spawning habitat is similar to Chinook salmon, NMFS expects that the proposed action will provide suitable quantity of coho salmon spawning habitat for successful spawning and egg incubation. While the proposed action will likely reduce the duration, magnitude and frequency of fine sediment mobilization from spawning gravel when IGD flows are below 10,000 cfs, adult coho salmon are able to clean fine sediment from spawning gravel (Kondolf et al. 1993, Kondolf 2012) prior to depositing eggs. Therefore, eggs in the mainstem Klamath River are not likely to be adversely affected by the proposed action.

Also, while the proposed action will likely reduce mainstem flows from October to December in less than average water years (> 45 percent exceedance; Table 11.8), coho salmon eggs in the mainstem are not expected to be dewatered because the average flow reductions are limited to approximately 70 to 140 cfs, which amounts to a stage height reduction at IGD of up to approximately 2.4 inches. The proposed action's ability to simulate flow variability at IGD and the naturally increasing flows during the winter from storm events downstream of IGD will further reduce the potential for dewatering of coho salmon eggs in the mainstem or side channels. In addition, redd dewatering is not expected to occur because of the conservative ramp-down rates proposed by Reclamation (NMFS 2002).

12.4.1.2.3 Fry

The proposed action is likely to adversely affect coho salmon fry by reducing habitat availability and increasing susceptibility to diseases. The amount and extent of these potential adverse effects are expected to vary spatially and temporally, and result primarily from proposed action effects on flow. These effects are discussed separately below for simplicity, but note that they can affect coho salmon fry simultaneously, sequentially, or synergistically. Also, note that the proposed action incorporates elements of flow variability, near real-time disease management, and restoration activities, which can help to offset some of the adverse effects from flow reductions.

12.4.1.2.3.1 Water Quality

As discussed in the *Effects to Essential Habitat Types* section (i.e., section 11.4.1.2.3.3), the proposed action's reduction of spring flows in the mainstem Klamath River is likely to increase water temperatures in the spring by up to approximately 0.5 °C in the mainstem between IGD and the Scott River (RM 143). Increases to water temperature in the spring may have both beneficial and adverse effects to coho salmon fry. Increasing water temperature in the spring may stimulate faster growth. However, when water temperature chronically exceeds 16.5 °C, coho salmon fry may become stressed and more susceptible to disease-related mortality (Foott et al. 1999, Sullivan et al. 2000, Campbell et al. 2001 *in* Ray et al. 2012, Ray et al. 2012, Hallett et al. 2012). Foott et al. (1999) found that when water temperatures are under 17 °C, Klamath River salmonids appear to be more resistant to ceratomyxosis. Therefore, the proposed action is likely to have minimal adverse effects to coho salmon fry when water temperatures are below 16.5 °C. Conversely, when daily maximum water temperatures are chronically above 16.5 °C in May to mid-June, the proposed action will contribute to water temperature conditions that will be stressful to coho salmon fry in the mainstem Klamath River between IGD and the Scott River (RM 143).

12.4.1.2.3.2 Habitat Availability

The relationship between habitat availability and effects on individuals is complex, and NMFS is limited in its ability to analyze these proposed action effects for a host of reasons. First, NMFS cannot quantify the exact magnitude of proposed action effects to habitat because no suitable modeling or other quantitative tool is available for NMFS to consider the suite of ecological and anthropogenic factors influencing density dependent effects on coho salmon.

Facing the same challenges, Reclamation (2012) evaluated habitat capacity for coho salmon fry using Hardy et al.'s (2006) data to calculate square feet of habitat in key mainstem reaches. Reclamation determined that the combined available fry habitat at the R Ranch and Trees of Heaven reaches had little change between 1,000 and 3,000 cfs, and that the proposed action will result in very similar available fry habitat as the variable base flow approach, which Reclamation

(2012) believes is representative of the RPA flows that NMFS prescribed in the 2010 BiOp (NMFS 2010a). Therefore, Reclamation concluded that the proposed action will most likely provide adequate quantities of suitable fry habitat.

NMFS identified limitations to Reclamation's habitat effects analysis, including (1) the use of Hardy et al.'s (2006) fry WUA curves instead of the revised ones (Hardy 2012) and (2) a lack of analysis of spatial, temporal, and environmental factors influencing habitat availability and the fitness of individuals. For example, Reclamation did not account for the number of coho salmon fry that enter the mainstem Klamath River from tributaries.

Both Reclamation's (2012a) analysis in the final BA and NMFS' analysis here on habitat effects are constrained due to the lack of a model that integrates habitat limitations to fish production through space and time. While fish production models have been developed specifically for the Klamath River, they have limited utility for NMFS' analysis because they are either not prepared to evaluate coho salmon (e.g., SALMOD), or they do not adequately incorporate the effects of habitat limitations on the survival and fitness of individuals (e.g., Cramer Coho Life Cycle Model). Therefore, NMFS has determined that a qualitative approach is most reasonable to evaluating proposed action effects on habitat availability, taking into account the complex interactions of potential environmental and anthropogenic factors described in the *Environmental Baseline* section.

As discussed in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section, the proposed action will reduce coho salmon fry habitat availability in the mainstem Klamath River between IGD (RM 190) to the Scott River (RM 143) in drier years (i.e., ≥60% exceedance) from March to June. In June, the proposed action reduces coho salmon fry habitat in the mainstem Klamath River between IGD (RM 190) to the Salmon River (RM 65.5) even under wetter conditions (up to 15 percent exceedance; Table 11.9).

Flow influences the width of the river channel and flow reductions likely reduce essential edge habitat, which decreases carrying capacities for coho salmon fry in the mainstem Klamath River. During the spring, coho salmon fry compete with other species (e.g., Chinook salmon) for available habitat. While habitat preferences between coho salmon fry are not the same as Chinook salmon, steelhead, and coho salmon juveniles, some overlap in habitat use is expected.

Based on literature, increased competition for space increases emigration rates or mortality (Chapman 1966, Mason 1976, Keeley 2001), and reduces growth rates (Mason 1976). Delayed growth results in a greater risk of individuals being killed by predators (Taylor and McPhail 1985). Coho salmon fry habitat in the mainstem Klamath River becomes increasingly important as the number of coho salmon fry in the mainstem increases in dry spring conditions because coho salmon fry move from low and warm water tributaries to the Klamath River. Generally, as the spring progresses from April through May, the number of coho salmon fry increases in the mainstem Klamath River downstream of the Shasta River (Chesney et al. 2007). When the density of coho salmon fry in the mainstem Klamath River are anticipated to be near or greater than habitat capacity, the proposed action will adversely affect coho salmon fry by increasing density dependent effects. Therefore, the proposed action will likely reduce growth and survival of coho salmon fry in the mainstem Klamath River between IGD and Salmon River (RM 66) from late March to mid-June when IGH salmonids are also in the mainstem.

Conversely, when conditions are favorable (e.g., good water quality, low juvenile abundance, low disease), the proposed action is likely to have minimal adverse effects to coho salmon fry. By mid-June, coho salmon fry are likely to have transformed from fry to parr, and coho fry abundance in the mainstem Klamath River in late June is likely at a level that habitat reductions resulting from the proposed action are minimal.

Given the abundance of coho salmon fry and juveniles is likely to be greatest in the mainstem Klamath River from April through June, Reclamation has proposed a precautionary approach to managing flows during the driest of conditions and has proposed to implement Hardy et al.'s (2006) recommended ecological base flows as minimums during the April through June period. During dry hydrologic conditions in the Klamath Basin, the proposed action will minimize adverse effects to coho salmon fry in April to June by not reducing flows in the mainstem Klamath River below what Hardy et al. (2006) considers to be acceptable levels of risk to the health of aquatic resources. Note that Hardy et al. (2006) did not quantitatively assess disease risks in the ecological base flow recommendation.

12.4.1.2.3.3 Disease

Ceratomyxosis, which is caused by the *C. shasta* parasite, is the focus for NMFS in the coho salmon disease analysis because researchers believe that this parasite is a key factor limiting salmon recovery in the Klamath River (Foott et al. 2009). Coho salmon in the Klamath River have coevolved with *C. shasta* and are relatively resistant to infection from this parasite (Hallett et al. 2012, Ray et al 2012). However, the high mortality of Klamath River salmonids from *C. shasta* is atypical (Hallett et al. 2012). Modifications to water flow, sedimentation, and temperature have likely upset the host-parasite balance in the Klamath River (Hallett et al. 2012).

NMFS believes the high incidence of disease in certain years within the mainstem Klamath River results largely from the reduction in magnitude, frequency, and duration of mainstem flows from the natural flow regime under which coho salmon evolved. The proposed action's effects on spring flows and channel maintenance flows and their relationship to disease are discussed below. Research on the effects of *C. shasta* on coho salmon juveniles is applicable to coho salmon fry because the parasite targets species not life stages (Hallett et al. 2012).

12.4.1.2.3.3.1 Spring Flows

The likelihood of coho salmon fry to succumb to ceratomyxosis is a function of a number of variables, such as temperature, flow, and density of actinospores (True et al. 2013). Ray et al. (2012) found that actinospore density, and then temperature, was the hierarchy of relative importance in affecting ceratomyxosis for juvenile salmonids in the Klamath River. When actinospore densities are high, thermal influences on disease dampen (Ray et al. 2012). Recent studies are further supporting the observation of a threshold for high infectivity and mortality of juvenile salmonids when the Klamath River actinospore density exceeds about 10 actinospores/L (Hallett and Bartholomew 2006, Ray et al. 2012). For coho salmon juveniles, actinospore genotype II density of 5 spores/L was the threshold where 40 percent of exposed coho salmon died (Hallett et al. 2012). When actinospore genotype II densities exceeded 5 spores/L, the percent of disease-related mortality significantly increased for juvenile coho salmon (Hallett et al. 2012). In addition, ceratomyxosis progressed more quickly in coho salmon when parasite levels in the water (i.e., genotype II actinospore density) increased (Hallett et al. 2012).

Actinospore density is likely to be influenced by spring flows and channel maintenance flows, both of which provide important ecological function in potentially minimizing disease prevalence of *C. shasta*. High spring flows likely dilute actinospores, and reduce transmission efficiency (Hallett et al. 2012). At a given actinospore abundance, higher flows will dilute spore concentrations. Fujiwara et al. (2011) found that the survival rate of IGH Chinook salmon was (1) significantly correlated with May 15 to June 15 stream flow in the mainstem Klamath River at Seiad Valley (RM 128), which is in the *C. shasta* infectious zone and (2) significantly lower than Trinity River Hatchery fish, which do not migrate through the infectious zone. These results support Fujiwara et al.'s (2011) hypothesis that ceratomyxosis has an impact on the subset of the salmon population that migrates through the infection zone. Fujiwara et al. (2011) also noted that higher June flows are correlated with higher winter flows, which likely scour fine sediment and likely reduce polychaete density in that substrate. Conversely, increased *C. shasta* infection has been correlated with decreased flows (Bjork and Bartholomew 2009).

In 2007 and 2008 when flows at IGD in May to June were below 1880 and 3060 cfs, respectively, up to 86 percent of the coho salmon juveniles died from *C. shasta* after being placed in a sentinel trap in the Klamath River upstream of the Beaver Creek confluence (RM 162) for 72 hours and then reared in a laboratory between 16 to 20 °C (Hallett et al. 2012, Ray et al. 2012). In a similar sentinel study, True et al. (2012) found coho salmon mortality from *C. shasta* to be 98.5 percent within 27 days after exposure to 72 hours of the Klamath River in 2008. NMFS is not confident sentinel study results are an exact representation of mortality rates for free swimming individuals. Nevertheless, disease risks were likely moderate or high for those juvenile coho salmon inhabiting areas of the mainstem Klamath River near Beaver Creek while the sentinel study was ongoing in 2007 and 2008.

In 2007, approximately 48 percent of the coho salmon young-of-the-year sampled[10] from the mainstem Klamath River were infected with *C. shasta* (Nichols et al. 2008). By assessing the pattern of *C. shasta* infections in the mainstem Klamath River, Nichols et al. (2008) believed that mortality from *C. shasta* of free swimming juvenile salmon in the mainstem Klamath River was likely moderate in 2007. In 2008, approximately 6 and 29 percent of the coho salmon young-of-the-year and yearlings, respectively, were infected with *C. shasta* (Nichols et al. 2009). However, Nichols et al. (2009) noted that the sample size for coho salmon in 2008 was small, and the results may not have been representative of infection rates for coho salmon that year. Nichols et al. (2009) suggested that actual coho salmon infection rates in 2008 were likely

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[10] NMFS excluded the yearling data because the sample size was low and the sampling period was not representative of the entire May to June period. Only sixteen yearlings were sampled in 2008, and all of them were sampled during the first two weeks of May. In addition, fourteen of the sixteen yearlings were sampled the first week of May.

similar to Chinook salmon infection rates since coho salmon have similar susceptibility to *C. shasta* as Chinook salmon (Stone et al. 2008). In 2008, 46 percent of the Chinook salmon sampled from the mainstem Klamath River between the Shasta River and Scott River in May and June were infected and up to 37 percent showed clinical infections (e.g., inflammatory tissue in >33% of the intestine section; Nichols et al. 2009).

As previously discussed in the *Hydrologic Effects* section (i.e., section 11.4.1.1), the proposed action generally reduces spring flows in the mainstem Klamath River downstream of IGD. By reducing spring flows, the proposed action will result in drier hydrologic conditions in the mainstem Klamath River relative to the natural hydrologic regime. Summer base flow conditions occur earlier than historically, with spring flows now receding precipitously in May and June, whereas the spring snow-melt pulse and the vast amount of upper Klamath Basin wetland historically attenuated flows in the Klamath River much more slowly into August or September. Therefore, when environmental conditions are conducive to actinospore release in the spring (e.g., elevated water temperature), the proposed action will likely result in hydrologic conditions in the mainstem Klamath River that contribute to high *C. shasta* actinospore concentrations (e.g., ≥5 spores/L actinospore genotype II), which will likely increase the percentage of disease-related mortality to coho salmon fry in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May to mid-June (Foot et al. 2008, Hallett et al. 2012, Ray et al. 2012). The proposed action will also likely increase the percentage of coho salmon fry in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to mid-June. Sublethal effects include impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections (Hallett et al. 2012).

NMFS notes that Reclamation added a near real-time disease management element to the proposed action for deviating from the formulaic approach and increasing spring flows when near-real-time monitoring shows that disease thresholds have been met and EWA surplus volume is available. Flow increases in the spring to avert potential risks of disease will occur through close coordination between the Services and Reclamation with consideration to potential effects to listed suckers. While NMFS cannot specifically predict the full range of hydrologic conditions when flow increases above the formulaic approach will occur, surplus EWA volume will likely be available in wet to below average hydrological water years. Because actinospore densities are likely low during above average and wet years, the proposed increase in spring flows will help dilute actinospore densities in the mainstem Klamath River below IGD during average and below average water years. Therefore, the real-time disease management element of the proposed action may minimize disease risks to coho salmon during average and below average water years. Note that when EWA surplus volume is used to increase spring flows, summer flows in the mainstem will be lower than modeled, depending on the amount of EWA surplus volume used for adaptively minimizing disease risks. However, minimum daily flows in the summer will not be affected by the near real-time disease management.

During dry water years, the proposed daily minimum flows for April, May and June will provide at least 1325 cfs, 1175 cfs, and 1025 cfs, respectively, at IGD for diluting actinospores. While these proposed minimum daily flows are not likely sufficient to dilute actinospore concentrations to below 5 genotype II spores/L when actinospore concentrations are high, these minimum daily flows provide a limit to the increase in disease risks posed to coho salmon under the proposed action, which may reduce disease-related mortality to coho salmon.

12.4.1.2.3.3.2 C*hannel Maintenance Flows*

Channel maintenance flows provide important ecological function. Channel maintenance flows flush fine sediment and provide restorative function and channel maintenance through scouring, which will likely reduce polychaete abundance and disturb their fine sediment habitat in the mainstem Klamath River. Fish health researchers (e.g., Stocking and Bartholomew 2007) have hypothesized high flow pulses in the fall and winter could have the added benefit of re-distributing salmonid carcasses concentrated in the mainstem below IGD, since infected adult salmon spread the myxospore life history stage of *C. shasta*. In addition, channel maintenance flows likely disrupt the ability of polychaetes to extract *C. shasta* spores (Jordan 2012). Bjork and Bartholomew (2009) found that higher water velocity resulted in lower *C. shasta* infections to the polychaete, and decreased infection severity in fish. Furthermore, channel maintenance flows that occur in the spring are likely to also dilute actinospores and reduce transmission efficiency (Hallett et al. 2012).

Recently, Wilzbach (2013) studied polychaete responses to short-term (i.e., 45 minutes) flow velocities in a flume, and concluded that polychaete populations likely exhibit high resiliency to flow-mediated disturbance events. Polychaetes employ a variety of behaviors for avoiding increases in flow, including extrusion of mucus, burrowing into sediments, and movement to lower flow microhabitats (Wilzbach 2013). Results from Wilzbach's (2013) study showed that few worms were dislodged at shear velocities below 3 cm/s on any substrate and above this level of shear, probability of dislodgement was strongly affected by both substrate type and velocity. Probability of dislodgement was greatest from fine sediments, intermediate from rock faces, and negligible for *Cladophora*. The short-term exposure of the polychaetes to flow velocities and the lack of multiple high flow exposures makes these results difficult to apply to the Klamath River. Therefore, NMFS relies on fish infection and disease data from the Klamath River to assess the proposed action's effects on disease prevalence.

A flow event in May-June of 2005 with a peak magnitude of approximately 5,000 cfs was enough discharge to disturb and remove a polychaete colony at Trees of Heaven, which had the highest maximum densities of all pools sampled (40,607/m^2; Stocking and Bartholomew 2007). However, the 2005 flow event was not enough to disrupt a reference polychaete population within aquatic vegetation (*Cladophora sp.*) upstream of the Tree of Heaven site. Therefore, much higher flows (i.e., flows described in section 11.4.1.1.4 that mobilize armored substances) are likely to be necessary to disturb the polychaete host in habitat types other than fine sediments, particularly polychaete colonies within aquatic vegetation (*Cladophora sp.*; Stocking and Bartholomew 2007).

The May 2005 flows and concurrent fish disease sampling exemplify the complex interaction described above. A rain-on-snow event raised IGD flows from 1,370 cfs to a peak of 5,520 cfs and sustained high flows for approximately 3 weeks. Prior to the channel maintenance flow event, *C. shasta* infection rates were approximately 75 percent in the Shasta to Scott River reach (Nichols et al. 2007). During the descending limb of the hydrograph, *C. shasta* infection rates decreased, culminating with a low of 32 percent in sampled fish at the Shasta to Scott River reach by June 15 when IGD flows were approximately 1,200 cfs (Nichols et al. 2007).

In a laboratory setting, Foott et al. (2007) exposed IGH Chinook salmon juveniles to Klamath River water in the spring of 2005 and found that *C. shasta* infections in Chinook salmon did not decline between April and June despite the high flows in May of 2005. Foott et al. (2007) then suggested that increasing spring flows is not effective at reducing parasite infection rates. NMFS notes that the laboratory data using Klamath River water (Foott et al. 2007) is not as ideal as data directly from fish sampled in the Klamath River. In addition, fish in the lab with Klamath River water were confined to a small area where fish cannot easily avoid actinospores (i.e., tanks were up to 15 liters [4 gallons]; Foott et al. 2007). Therefore, NMFS relies again on data from the Klamath River (Nichols et al. 2007) to assess the proposed action's effects on disease prevalence.

High winter and spring flows in 2006 when IGD flows exceeded 10,000 cfs resulted in a general reduction in seasonal disease rates and a delay in the peak infection rates among juvenile salmonids in the mainstem Klamath River. Flows at IGD in the spring of 2006 may have influenced disease infection rates by: (1) reducing the abundance of polychaete colonies due to the scouring of slack water habitats and *Cladophora* beds, (2) diluting *C. shasta* actinospore concentrations; and/or (3) reducing the transmission/infection efficiency of the parasites due to environmental conditions (temperature, turbidity, velocity).

As discussed in the *Hydrologic Effects* section (i.e., section 11.4.1.1.4), the proposed action will increase the magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs relative to the observed POR (e.g., the proposed action will have an estimated two year flood frequency of 5,454 cfs whereas the observed POR had 5,168 cfs). When compared to the observed POR, the increase in magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs under the proposed action will likely decrease the abundance of polychaetes in the spring and summer following a channel maintenance flow event. In addition, the increase in magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs under the proposed action will likely decrease the actinospore concentrations relative to the observed POR when the channel maintenance flow event occurs in the spring, particularly in May and June.

However, the proposed action will decrease the duration of channel maintenance flows between 5,000 and 10,000 cfs relative to the observed POR (e.g., an average reduction of 7 days per year with flows between 5,000 and 10,000 cfs), which will reduce the actinospore dilution effect of high flows since the channel maintenance flows generally occur in the spring. Fewer days of channel maintenance flows mean fewer days of actinospore dilution, which will likely increase the density of actinospores in the May through June weeks following the high flow event.

The proposed action's net disease effect to coho salmon from these varying hydrologic changes to channel maintenance flows between 5,000 and 10,000 cfs is unclear, but is likely to be improved over the observed POR because the increased magnitude and frequency of high flows will provide more intense and frequent disturbance to polychaetes and sediment. Meanwhile, the shorter duration of high flows may not necessarily decrease the relative effectiveness of polychaete and sediment disturbance because the effectiveness of sediment mobilization generally diminishes with longer duration of high flows (e.g., sediment supply depletes). In addition, Holmquist-Johnson and Milhous (2010) identified needing high flows for a period of days to flush fine sediments in the Klamath River, which will be provided despite the shortened duration under the proposed action (i.e., the proposed action modeled results show an average of 35 days of flows between 5,000 and 10,000 cfs in years with these flows). Therefore, the increased magnitude and frequency of high flows will likely be effective at minimizing disease risks despite the shortened duration of high flows.

Nevertheless, the proposed action will continue to contribute to hydrologic conditions (e.g., reduced magnitude, frequency and duration of peak flows below 10,000 cfs relative to the natural flow regime) that allow *C. shasta* to proliferate in the mainstem Klamath River and reduce coho salmon fry fitness or survival. Although the proposed action will result in a two-year flood frequency of 5,454 cfs (Table 11.7), the proposed action will decrease the probability of achieving channel maintenance flows in the mainstem Klamath River relative to the natural flow regime when storage capacity is not limiting, especially during consecutive dry years. Therefore, during consecutive dry years, the proposed action will likely result in increased fine sediment deposition, increased establishment of aquatic vegetation downstream from IGD, and likely decreased dilution of actinospores in the spring. All of these factors create favorable conditions for infecting coho salmon with *C. shasta* (Stocking and Bartholomew 2006, Ray et al. 2012).

12.4.1.2.3.3.3 Summary

NMFS believes the high incidence of disease for rearing coho salmon in certain years within the mainstem Klamath River results largely from the reduction in magnitude, frequency, and duration of mainstem flows from the natural flow regime under which the fish evolved. The proposed action will generally reduce spring flows in the mainstem Klamath River downstream of IGD relative to the natural flow regime. By reducing spring flows, the proposed action will decrease the diluting effect of high spring flows, will likely lead to high *C. shasta* actinospore concentrations (e.g., ≥5 spores/L actinospore genotype II), and will likely increase the percentage of disease-related mortality to coho salmon fry in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May to mid-June (Foot et al. 2008, Hallett et al. 2012, Ray et al. 2012). Decreased spring flows under the proposed action will also likely increase the percentage of coho salmon fry in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to mid-June. In addition, the proposed action will continue to contribute to reduced duration, magnitude, and frequency of peak flows below 10,000 cfs relative to the natural flow regime, which will likely allow *C. shasta* to proliferate in the mainstem Klamath River under certain environmental conditions (e.g., high water temperatures in the Klamath River and below average water years) and increase infection and disease-related mortality to coho salmon fry in the mainstem Klamath River, especially during consecutive dry years.

However, the real-time disease management element of the proposed action is likely to partially offset the increased disease risks to coho salmon during average and below average water years, and the minimum daily flows provide a limit to the increase in disease risks posed to coho salmon under the proposed action. While NMFS cannot quantify the magnitude of the increased disease risk to coho salmon under the proposed action, based on the reasons discussed above, NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions.

12.4.1.2.3.4 Flow Variability

As discussed in the *Hydrologic Effects* section (i.e., section 11.4.1.1.3), the proposed action will result in a mainstem Klamath River hydrograph that approximates the natural flow variability of the upper Klamath Basin. Under the proposed action, the extent of the flow variability in the mainstem Klamath River will be representative of natural hydrologic conditions in the upper Klamath Basin (e.g., mainstem flows will increase when snow melt, precipitation, or both increases in the upper Klamath Basin). For example, when the upper Klamath Basin is experiencing relatively wet hydrologic conditions, flows in the mainstem Klamath River will be relatively high seven days later. Conversely, when the upper Klamath Basin is experiencing relatively dry hydrologic conditions, flows in the mainstem Klamath River will be relatively low seven days later. The effects of the proposed action on flow variability will be greatest proximal to IGD and diminish longitudinally, as tributary accretions contribute to the volume of water and impart additional flow variability.

Flow variability is an important component of river ecosystems which can promote the overall health and vitality of both rivers and the aquatic organisms that inhabit them (Poff et al 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Arthington et al. 2006). Arthington et al. (2006) stated that simplistic, static, environmental flow rules are misguided and will ultimately contribute to further degradation of river ecosystems. Variable flows trigger longitudinal dispersal of migratory aquatic organisms and other large flow events allow access to otherwise disconnected floodplain habitats (Bunn and Arthington 2002), which can increase the growth and survival of salmon fry (Jeffres et al. 2008).

The proposed action will result in more natural and variable fall and spring flows that better represent climate conditions, and will provide transitory habitat in side-channels and margins preferred by coho salmon fry when flows increase in the spring. Transitory habitat in side channels and margins is expected to provide suitable cover from predators, and ideal feeding locations.

Variable flows, including small variations, provide dynamic fluvial environments in the mainstem Klamath River that may impair polychaete fitness, reproductive success, or infection with *C. shasta*. Since polychaetes appear to prefer stable hydrographs (Strange 2010b, Jordan 2012), flow variability will likely decrease polychaete habitat. In addition, polychaetes must extract *C. shasta* myxospores from the water to become infected (Jordan 2012). Increased flow variability may increase water velocity where polychaetes may have increased difficulty extracting myxospores or colonizing habitat. If sufficiently large, increased flow variability under the proposed action will likely help disrupt the fine sediment habitat of *M. speciosa* and increase the redistribution of adult salmon carcasses in the mainstem Klamath River, which will likely reduce polychaetes in the mainstem Klamath River. In addition, when the upper Klamath Basin is experiencing relatively wet hydrologic conditions in the spring, flow variability under the proposed action will result in a relatively smaller reduction to mainstem flows during the spring, which will likely result in a relatively smaller increase in *C. shasta* actinospore concentrations, a smaller reduction to habitat availability for coho salmon fry, a smaller reduction to migration rate and survival of smolts, and a smaller reduction to water quality impairment than when the upper Klamath Basin is experiencing relatively drier hydrologic conditions in the spring. Therefore, flow variability under the proposed action is likely to minimize the proposed action's adverse effects from reductions to mainstem Klamath River flows when wet hydrological conditions occur in the upper Klamath Basin (e.g., precipitation and snow melt).

12.4.1.2.3.5 Ramp-down Rates

Rapid ramp-down of flows can strand coho salmon fry and juveniles if mainstem flow reductions accelerate the dewatering of lateral habitats. Stranded coho salmon fry disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of coho salmon fry and juveniles can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry and juveniles are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel.

NMFS expects the proposed ramp-down rates when flows at IGD are greater than 3,000 cfs will generally reflect natural flow variation since the ramp-down rates follow the rate of decline of inflows into UKL and combine with accretions between Keno Dam and IGD. NMFS expects any stranding that may occur at these higher flows to be consistent with rates that would be observed under natural conditions. NMFS concluded in the 2002 and 2010 BiOps (NMFS 2002, 2010a) that the proposed ramp-down rates below 3,000 cfs adequately reduce the risk of stranding coho salmon fry. Therefore, NMFS continues to conclude that Reclamation's proposed ramp-down rates are not likely to adversely affect coho salmon fry and juveniles and thus does not analyze this part of the proposed action further in this BiOp.

12.4.1.2.4 Juvenile

Hydrologic and habitat changes can strongly affect juvenile fish survival in riverine systems (Schlosser 1985, Nehring and Anderson 1993, Mion et al. 1998, Freeman et al. 2001, Nislow et al. 2004). Of all the coho salmon life stages, juveniles are the most exposed to the hydrologic effects of the proposed action. Up to 50 percent of the total parr (i.e., from mainstem redds or tributaries) population will be affected in the mainstem Klamath River, while all smolts will use the mainstem Klamath River to outmigrate to the ocean.

The proposed action will likely adversely affect coho salmon juveniles by decreasing water quality (e.g., increasing water temperature, decreasing dissolved oxygen concentration), increasing susceptibility to diseases, delaying outmigration times, and reducing habitat availability. The amount and extent of these potential adverse effects are expected to vary spatially and temporally, and result primarily from proposed action effects on flow. These effects are discussed separately below for simplicity. However, note that they are interrelated and can affect coho salmon juveniles simultaneously, sequentially, or synergistically. Also, note that the proposed action incorporates elements of flow variability, real-time disease management, and restoration activities, which can help to offset some of the adverse effects from flow reductions.

12.4.1.2.4.1 Water Quality

Increases to water temperature in the spring may have both adverse and beneficial effects to coho salmon juveniles. When water temperatures chronically exceed 16.5 °C, coho salmon juveniles may become stressed (Sullivan et al. 2000, Campbell et al. 2001 *in* Ray et al. 2012). However, increasing water temperature in the spring may also stimulate faster growth (Dunne et al. 2011) and smolt outmigration (Hoar 1951, Holtby 1988, Moser et al. 1991, Clarke and Hirano 1995), which may reduce exposure to actinospores and other pathogens in the mainstem Klamath River. For reasons similar to those discussed for water temperature effects on coho salmon fry (i.e., section 12.4.1.2.3.1), when daily maximum water temperatures become chronically above 16.5 °C in May to June, the proposed action will contribute to water temperature conditions that will be stressful to coho salmon juveniles in the mainstem Klamath River between IGD and the Scott River (RM 143).

Low dissolved oxygen concentration can impair growth, swimming performance and avoidance behavior (Bjornn and Reiser 1991). Davis (1975) reported effects of dissolved oxygen levels on salmonids, indicating that at dissolved oxygen concentrations greater than 7.75 mg/L salmonids functioned without impairment, at 6.0 mg/L onset of oxygen-related distress was evident, and at 4.25 mg/L widespread impairment is evident. At 8 mg/L, the maximum sustained swimming performance of coho salmon decreased (Davis et al. 1963, Dahlberg et al. 1968). Low dissolved oxygen can affect fitness and survival by increasing the likelihood of predation and decreasing feeding activity (Carter 2005). Sublethal effects include increased stress, reduced growth, or no growth, and are expected for coho salmon parr that are in the mainstem Klamath River below IGD during the summer and fall.

As discussed in the *Effects to Essential Habitat Types* section, when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD (RM 190) and Orleans (RM 59). Coho salmon juveniles in the mainstem Klamath River between IGD and Orleans will be exposed to the reduced dissolved oxygen concentrations at night and early morning when they are not confined to thermal refugia at tributary confluences. Therefore, the proposed actions' contributions to low dissolved oxygen concentrations in the summer will adversely affect swimming performance (at ≤ 8.0 mg/L) and increase stress (at ≤ 6.0 mg/L) to coho salmon juveniles in the mainstem between IGD (RM 190) and Orleans (RM 59) during this period.

12.4.1.2.4.2 Disease

Similar to the discussion on disease effects on coho salmon fry (i.e., section 12.4.1.2.3.3), when environmental conditions are conducive to actinospore release in the spring (e.g., elevated water temperature), the proposed action will result in hydrologic conditions in the mainstem Klamath River that likely support high *C. shasta* actinospore concentrations (e.g., ≥5 spores/L actinospore genotype II) that lead to mortality of coho salmon juveniles in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May and June (Foott et al. 2008, Hallett et al. 2012, Ray et al. 2012). In addition, the proposed action will also likely increase the percentage of coho salmon juveniles in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to August (Foott et al. 2008, Hallett et al. 2012).

12.4.1.2.4.3 Thermal refugia

Thermal refugia along the mainstem provide salmon essential locations where coho salmon juveniles can seek refuge when water temperatures in the mainstem become excessive (Tanaka 2007). Without thermal refugia, mainstem flows alone could not support salmonid populations in the summer because of the high water temperatures in the mainstem Klamath River (Sutton et al. 2007). Coho salmon juveniles use refugial habitat in both the mainstem Klamath River and non-natal tributaries as refuge from critically high mainstem Klamath River water temperatures in the summer (Sutton et al. 2007, Soto et al. 2008, Sutton and Soto 2010). Sutton and Soto (2010) found that coho salmon juveniles began using thermal refugia when the mainstem Klamath River temperature approached approximately 19 °C. Similarly, Hillemeier et al. (2009) found that coho salmon started entering Cade Creek, a cooler tributary, when mainstem Klamath River temperature exceeded about 19 °C.

When coho salmon juveniles in the mainstem cannot access cooler tributaries, they can face elevated stress from mainstem temperatures, degraded water quality, competition with other salmonids for mainstem thermal refugia, and higher susceptibility to pathogens such as *C. shasta*. Mainstem thermal refugia provide coho salmon relief from temperature and poor water quality (e.g., high pH and low dissolved oxygen concentrations). However, mainstem thermal refugia do not provide coho salmon relief from susceptibility to *C. shasta* if actinospore densities are high (Ray et al. 2012).

The primary factor affecting the integrity of thermal refugia is the tributary flows, which are not affected by the proposed action. The higher the tributary flows, the larger the thermal refugia will be in the mainstem Klamath River. Tributaries that historically provided cold water accretions to the mainstem Klamath River produce appreciably less water to the mainstem Klamath River due to water diversions, provide less non-natal rearing habitat (e.g., Shasta and Scott River), and reduce the amount of available thermal refugia in the mainstem.

While the proposed action does not affect the amount or timing of tributary flows, the proposed action can influence both the size of refugial habitat in the mainstem Klamath River as well as influence the connectivity between tributaries and the mainstem. When the proposed action decreases mainstem flows in the summer, water temperature becomes more influenced by meteorological conditions, which will increase daily maximum and median (to a lesser extent) water temperatures. Elevated water temperatures in the summer may temporarily reduce the size of thermal refugia in the mainstem (Ring and Watson 1999, Ficke et al. 2007, Hamilton et al 2011). On the other hand, the NRC (2002 and 2004) hypothesized that increasing mainstem flows in the Klamath River might reduce the size of thermal refugia because of the warm water temperatures out of IGD.

Sutton et al. (2007) studied the effects of flow on thermal refugia in the mainstem Klamath River, and ultimately suggested that thermal refuge area could be modified under variable flows. With limited empirical data and inconclusive results (Sutton et al. 2007), it is unclear whether mainstem flow increases or decreases will affect thermal refugial size. Therefore, NMFS is unable to reach a conclusion regarding the effects of the proposed action relative to thermal refugial size, except as described below for the mainstem downstream of Seiad Valley.

NMFS can reasonably assume that the proposed minimum summer flow of approximately 900 cfs from IGD is likely to result in insignificant effects to mainstem thermal refugial size downstream of Seiad Valley for several reasons. First, the effects of IGD flows on thermal refugia diminishes with increasing distance downstream due to tributary accretion, larger channel size, and less stable alluvial channels (Sutton et al. 2007). Second, flow volume at IGD can alter the diurnal pattern of water temperatures within the Klamath River. However, the effect is most pronounced upstream of the Shasta River and is significantly reduced by the time flows reach Seiad Valley (RM 129; PacifiCorp 2006). Third, NMFS considers coho salmon parr use of mainstem thermal refugial habitat (i.e., tributary confluences or cold water plumes at tributary confluences) within the Middle and Lower Klamath River reaches to be uncommon, since no fish have been observed in these areas during past thermal refugial studies (Sutton et al. 2004, Sutton et al. 2007, Strange 2010a, Strange 2011). For these reasons, NMFS anticipates the proposed July through September flow regime is not likely to adversely affect coho salmon parr located within the downstream half of the Middle Klamath River and the entire lower Klamath River reaches.

In addition, NMFS notes that access to tributaries is important for coho salmon juveniles in the summer to seek thermal refuge, and that the lower the mainstem flows, the less likely coho salmon juveniles can access tributaries. Sutton and Soto (2010) documented several Klamath River tributaries (i.e., Cade [RM 110] and Sandy Bar [RM 76.8] creeks) where fish access into the creeks were challenging, if not impossible, when IGD flows were 1000 cfs in the summer. Because of their alluvial steepness, NMFS acknowledges that some tributaries (e.g., Sandy Bar Creek) may not be conducive to access until flows are very high, which may not be possible in the summer even under natural conditions.

As described in the *Effects to Essential Habitat* section (i.e., section 11.4.1.2.2), stage height-flow relationship data at mainstem Klamath River gage sites (e.g., Klamath River at Seiad or Orleans), indicate that, during low summer flow conditions, 100 cfs influences the Klamath River stage height by 0.1 to 0.13 feet. Given the minimal effect on stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile accessing tributaries.

12.4.1.2.4.4 Habitat Availability

Reclamation (2012) evaluated habitat capacity for coho salmon juveniles using Hardy et al.'s (2006) data to calculate square feet of habitat in key mainstem reaches. Reclamation then applied Nickelson's (1998) estimate of juvenile coho salmon habitat capacity (two fish per square meter of pool habitat) to determine if habitat capacity is limited under the proposed action. Reclamation estimated that the proposed action would result in flows that could support over 20,000 coho salmon in the mainstem Klamath River in the R Ranch and Trees of Heaven reaches. Assuming 50 coho salmon redds in the mainstem Klamath River, Reclamation estimated that 9,000 natural origin coho salmon juveniles resulting from mainstem spawning may be present in the mainstem. Based on the available habitat, Reclamation concluded that the proposed action will likely provide adequate habitat for natural-origin juvenile coho salmon during the spring until the annual hatchery goal of 75,000 IGH coho salmon juveniles are released into the mainstem Klamath River between March 15 and May 1 (CDFG 2012 *in* Reclamation 2012). Although Reclamation (2012) did not analyze competition or predation by hatchery-origin or natural-origin Chinook salmon and steelhead, Reclamation (2012) acknowledged that coho salmon juveniles rearing in the mainstem will experience decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities following the release of approximately 75,000 hatchery-origin coho salmon.

NMFS concurs with Reclamation's assessment that habitat availability for juveniles in the mainstem Klamath River is most critical between March to June because of: (1) the spring redistribution of coho salmon parr; (2) the presence of most, if not all, coho salmon smolts from the Interior Klamath Diversity Stratum in the mainstem during this time; and (3) the presence of other stressors, such as the addition of IGH salmonids, the onset of elevated water temperatures, and disease prevalence. During the spring, natural origin coho salmon parr and, to a lesser extent, smolts compete for habitat with natural origin and hatchery-released salmon and steelhead in late March to June. Competition for habitat peaks during May and early June when natural origin smolts co-occur with approximately five million Chinook salmon smolts from IGH. Therefore, habitat availability during spring is the most essential for coho salmon juveniles.

During the fall (i.e., October and November), coho salmon parr migrate through mainstem habitat as they redistribute from thermally suitable, summer habitat into winter rearing habitat characterized by complex habitat structure and low water velocities in tributaries (Lestelle 2007). The presence of coho salmon juveniles in the mainstem Klamath River is likely low in the fall and winter, and habitat availability in the mainstem Klamath River during the fall and winter is not considered limited. During the summer, coho salmon juveniles in the mainstem are limited to thermal refugia during the day, and habitat availability in the mainstem Klamath River during the summer is not considered limited for the relatively fewer coho salmon parr rearing in the mainstem during this period.

The amount of rearing habitat available in the mainstem Klamath River is correlated with flows, especially at certain ranges where water velocity, depth, and cover provide suitable conditions for fry and juvenile rearing (Figures 11.17 and 11.18). As discussed earlier in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section, the Trees of Heaven, Seiad Valley, and Rogers Creek reaches all show reduced habitat availability as a result of the proposed action. Further downstream at the Rogers Creek reach, the proposed action will reduce habitat availability between March and June in average water years (≥50 percent exceedance; Table 11.12) and in above average water years for the latter spring months (Table 11.12).

Higher flows (i.e., spring, summer, or total annual) likely provide more suitable habitat for juvenile growth and survival through increased production of stream invertebrates and availability of cover (Chapman 1966, Giger 1973). Reductions in spring flows can disconnect floodplains from rivers and reduce habitat availability and quality from floodplains (Sommer et al. 2001 and 2004, Opperman et al. 2010). By decreasing mainstem Klamath River flows, the proposed action reduces the extent of value floodplains provide to coho salmon. Healthy floodplains provide a number of resources, such as cover, shelter, and food, for rearing juveniles (Jeffres et al. 2008). Floodplain connectivity provides velocity refuge for juveniles to avoid high flows, facilitates large wood accumulation into rivers that form complex habitat (e.g., cover and pool), and provides off-channel areas with high abundance of food and fewer predators (NMFS 2012c).

Habitat availability and quality are essential for coho salmon growth and survival. Habitat quality exerts a significant influence on local salmonid population densities (Bilby and Bisson 1987). In addition, as habitat decreases, coho salmon juveniles are forced to use less preferable habitat, emigrate, or crowd, especially if habitat capacity is reached. All of these options likely have negative consequences for coho salmon juveniles. The use of less preferable habitat decreases the fitness of coho salmon juveniles and increases their susceptibility to predation. Conversely, the success and fitness of individuals is the ultimate index of habitat quality (Winker et al. 1995). Emigration of coho salmon juveniles prior to their physiological readiness for saltwater likely diminishes their chance of survival (Chapman 1966, Kennedy et al. 1976 *in* Koski 2009).

The probability of observing density-dependent response in juvenile salmonids (i.e., growth, mortality or emigration) increases with the percent of habitat saturation. Strong positive correlations have also been found between total stream area (i.e., a habitat index) and coho salmon biomass (Pearson et al. 1970, Burns 1971). Fraser (1969) found that coho salmon density is inversely correlated with juvenile coho salmon growth and survival. Weybright (2012) found that coho salmon density was negatively associated with coho salmon growth in a southern Oregon coastal basin. These studies are consistent with the understanding that juvenile growth is affected by interactions between competition and habitat quality (Keeley 2001, Rosenfeld and Boss 2001, Harvey et al. 2005, Rosenfeld et al. 2005).

Growth and body size are important for juvenile coho salmon, and likely have a strong influence on the individual fitness of subsequent life stages (Ebersole et al. 2006). Studies on juvenile salmonids indicate that larger body size and fitness increases the probability of survival (Hartman et al. 1987, Lonzarich and Quinn 1995; Quinn and Petersen 1996; Zabel and Achord 2004; Ebersole et al. 2006, Roni et al. 2012). Increased growth confers higher over-wintering survival for larger individuals than for smaller individuals (Quinn and Peterson 1996). Larger smolts also have a greater likelihood of surviving in the ocean than smaller smolts (Bilton et al. 1982, Henderson and Cass 1991, Yamamoto et al. 1999, Zabel and Williams 2002, Lum 2003, Jokikokko et al. 2006, Muir et al. 2006, Soto et al 2008). In addition, larger smolts tend to produce larger adults (Lum 2003, Henderson and Cass 1991), which have higher fecundity than smaller adults (Weitkamp et al. 1995, Fleming 1996, Heinimaa and Heinimaa 2004).

Based on literature, increased competition for space increases emigration rates or mortality rates (Chapman 1966, Mason 1976, Keeley 2001), and reduces growth rates (Mason 1976). Delayed growth results in a greater risk of individuals being killed by predators (Taylor and McPhail 1985). Coho salmon juvenile habitat in the mainstem Klamath River becomes increasingly important as exposure of individuals increases in dry spring conditions, and juveniles move from tributaries to the Klamath River. Generally, as the spring progresses from April through May, the number of coho salmon juveniles increases in the mainstem Klamath River downstream of the Shasta River (Chesney et al. 2007). When the density of coho salmon juveniles in the mainstem Klamath River are anticipated to be near or greater than habitat capacity, the proposed action will adversely affect coho salmon juveniles by increasing density dependent effects. Under these conditions, the proposed action will likely reduce growth and survival of coho salmon juveniles in the mainstem Klamath River between the Trees of Heaven (RM 172) and Rogers Creek (RM 72) in March to June. Conversely, when conditions are favorable (e.g., good water quality, low juvenile abundance, low disease), the proposed action will have minimal adverse effects to coho salmon juveniles (early March and prior to IGH Chinook salmon release).

12.4.1.2.4.5 Migration and Survival

Coho salmon juveniles begin the smoltification process by less vigorously defending their territories and forming aggregations (Sandercock 1991) while moving downstream (Hoar 1951). Several other physiological and behavioral changes also accompany smoltification of Pacific salmonids, including negative rheotaxis (i.e., facing away from the current) and decreased swimming ability (McCormick and Saunders 1987). These physiological and behavioral changes support the expectation that coho salmon smolts outmigrate faster with higher flows and experience higher survival (NMFS 2002) because of decreased exposure to predation (Rieman et al 1991), and disease pathogens (Cada et al. 1997). Beeman et al. (2012) monitored migration and survival of hatchery and wild coho salmon from 2006 to 2009, and found that discharge had a positive effect on passage rate on the mainstem Klamath River from the release site near IGD to the Shasta River. In addition, the median travel time for wild coho salmon juveniles from the release site to the Klamath River estuary was 10.4 days in 2006 when IGD flows exceeded 10,000 cfs, whereas the median travel time for wild coho salmon in 2009 was 28.7 days when IGD flows were less than 2,000 cfs. More importantly, Beeman et al. (2012) found that increasing discharge at IGD had a positive effect on survival of coho salmon smolts in the mainstem reach upstream of the Shasta River, and the positive effect of discharge decreased as water temperature increased.

Beeman et al.’s (2012) findings are consistent with other studies or reviews that have shown that increased flow (either total annual, spring or summer) results in increased smolt migration (Berggren and Filardo 1993, McCormick et al. 1998) or survival (Burns 1971, Mathews and Olson 1980, Scarneccia 1981, Giorgi 1993, Čada et al. 1994, Lawson et al. 2004). Berggren and Filardo (1993) found a significant correlation between average flow and smolt migration time in the Columbia River. Scarneccia (1981) found a highly significant positive relationship between total stream flows, and the rate of survival to the adult life stage for coho salmon in five Oregon rivers. Mathews and Olson (1980) documented a positive correlation between summer streamflow and survival of juvenile coho salmon. Lawson et al. (2004) found that spring flows correlated with higher natural smolt production on the Oregon Coast. Increases in summer flows, along with stabilizing winter flows, have led to increased production of coho salmon (Lister and Walker 1966; Mundie 1969), while Burns (1971) found that highest mortality of coho salmon in the summer occurred during periods of lowest flows.

By reducing spring flows in the mainstem Klamath River, the proposed action decreases survival and passage rate in the reach between IGD and the mouth of the Shasta River (RM 176) when flows at IGD are between 1,020 and 10,300 cfs, as supported by data from Beeman et al. (2012). The decrease in survival is likely a result of increased exposure to stressors in the mainstem Klamath River. Some of these adverse effects will be minimized by the flow variability incorporated into the proposed action when precipitation and snow melt occurs in the upper Klamath Basin.

12.4.1.2.4.6 Flow Variability

The beneficial effects of flow variability described earlier for coho salmon fry (i.e., section 12.4.1.2.3.4) also apply to coho salmon juveniles. In addition, juvenile coho salmon will be provided environmental cues with variable flows under the proposed action, and will likely redistribute downstream to abundant overwintering habitat in the lower Klamath River reach and downstream non-natal tributaries during the fall.

12.4.1.3 Risk

The proposed action will likely result in increased risks to coho salmon individuals. Of all the different life stages, coho salmon fry and juveniles (parr and smolts) face the highest risks from the hydrologic effects of the proposed action, especially during the spring (Table 12.6). Risks to smolts apply to both IGH coho salmon and natural origin coho salmon from populations in the Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon rivers. Risks to coho salmon fry and juveniles from the Salmon River population are the least since most of the adverse effects of the proposed project diminish in the mainstem Klamath River at Orleans (RM 59).

Table 12.6. Summary of risks resulting from the proposed action to coho salmon life stages.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location
Habitat Reduction	Increased likelihood of reduced growth or survival to some individuals	Fry	Late March to mid-June	IGD (RM 190) to Salmon River (RM 66)
		Parr and Smolts	March to June	Trees of Heaven (RM 172) to Rogers Creek (RM 72)
Disease (*C. shasta*)	Increased likelihood of impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections	Fry	April to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)
		Parr	April to August	
		Smolts	April to June	
	Increased likelihood of disease-related mortality	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)
		Parr, and Smolts	May to June	
Elevated water temperature	Increased stress	Fry	May to mid-June	IGD to Scott River (RM 143)
		Parr and Smolts	May to June	
DO reduction	Decreased swimming performance and increased stress	Parr	June to August	IGD (RM 190) to Orleans (RM 59)
Decreased outmigration rates	Increased likelihood of mortality from other stressors in the mainstem Klamath River (e.g., disease, predation, impaired water quality)	Smolts	April to June	IGD (RM 190) to Shasta River (RM 176)

12.4.2 Restoration Activities

Restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1. The specific timing and duration of each individual restoration project will vary depending on the project type, specific project methods, and site conditions. However, the duration and magnitude of effects to coho salmon and their designated critical habitat associated with implementation of individual restoration projects will be significantly minimized due to the multiple proposed avoidance and minimization measures.

Implementing individual restoration projects during the summer low-flow period will significantly minimize exposure to emigrating coho salmon smolts and coho salmon adults at all habitat restoration project sites. The total number and location of restoration projects funded annually will vary from year to year depending on various factors, including project costs, funding and scheduling. Assuming the number of restoration activities is similar to PacifiCorp's coho enhancement fund, the total number of projects expected to be implemented each year should range between four and six, depending on what projects get selected and the cost of each of those projects.

Except for riparian habitat restoration and water conservation measures (see section 11.4.2.1), all proposed restoration types, while implemented for the purpose of benefiting coho salmon and restoring their designated critical habitat on a long-term basis, have the potential to result in short-term adverse effects. Despite the different scope, size, intensity, and location of these proposed restoration actions, the potential adverse effects to coho salmon all result from dewatering, fish relocation, structural placement, and increased sediment. Dewatering, fish relocation, and structural placement may result in direct effects to listed salmonids, where a small percentage of individuals may be injured or killed. The effects from increased sediment mobilization into streams are usually indirect effects, where the effects to habitat, individuals, or both, are reasonably certain to occur and are later in time.

12.4.2.1 Dewatering

Although all project types include the possibility of dewatering, not all individual project sites will need to be dewatered. When dewatering is necessary, only a small reach of stream at each project site will be dewatered for instream construction activities. Dewatering encompasses placing temporary barriers, such as a cofferdam, to hydrologically isolate the work area, re-routing stream flow around the dewatered area, pumping water out of the isolated work area, relocating fish from the work area (discussed separately), and restoring the project site upon project completion. The length of contiguous stream reach that will be dewatered for most projects is expected to be less than 500 feet and no greater than 1000 feet for any one project site.

12.4.2.1.1 Exposure

Because the proposed dewatering would occur during the low flow period, the life stage most likely to be exposed to potential effects of dewatering is juvenile coho salmon. Dewatering is expected to occur mostly during the first half of the instream construction window (e.g., to accommodate for the necessary construction time needed), and therefore should avoid exposure to adult coho salmon. Dewatering that occurs in the latter half of the instream construction window may expose early incoming coho salmon to displacement. However, adult coho salmon are not likely to be affected because adults will avoid the construction area and dewatering is very rarely done so late in the low flow season.

12.4.2.1.2 Response

If coho salmon juveniles are present, the adverse effects of dewatering result from the placement of the temporary barriers, the trapping of individuals in the isolated area, and the diversion of streamflow. Fish relocation and ground disturbance effects are discussed further below. Rearing juvenile coho salmon could be killed or injured if crushed during placement of the temporary barriers, such as cofferdams, though crushing is expected to be minimal due to evasiveness of most juveniles. Stream flow diversions could harm salmonids by concentrating or stranding them in residual wetted areas (Cushman 1985) before they are relocated, or causing them to move to adjacent areas of poor habitat (Clothier 1953, Clothier 1954, Kraft 1972, Campbell and Scott 1984). Juvenile coho salmon that are not caught during the relocation efforts would be killed from either construction activities or desiccation.

Changes in flow are anticipated to occur within and downstream of restoration sites during dewatering activities. These fluctuations in flow, outside of dewatered areas, are anticipated to be small, gradual, and short-term, which should not result in any harm to salmonids. Stream flow in the vicinity of each project site should be the same as free-flowing conditions, except during dewatering and in the dewatered reach where stream flow is bypassed. Stream flow diversion and project work area dewatering are expected to cause temporary loss, alteration, and reduction of aquatic habitat.

Dewatering may result in the temporary loss of rearing habitat for juvenile salmonids. The extent of temporary loss of juvenile rearing habitat should be minimal because habitat at the restoration sites is typically degraded and the dewatered reaches are expected to be less than 500 feet per site and no more than a total of 1000 feet per project. These sites will be restored prior to project completion, and should improve relative to current condition by the restoration.

Effects associated with dewatering activities will be minimized due to the multiple minimization measures that will be used as described in the section entitled, *Measures to Minimize Impacts to Aquatic Habitat and Species during Dewatering of Projects* within Part IX of the Restoration Manual (Flosi et al. 2010).

12.4.2.1.3 Risk

Juvenile coho salmon that avoid capture in the project work area will die during dewatering activities. NMFS expects that the number of coho salmon that will be killed as a result of barrier placement and stranding during site dewatering activities is very low, likely less than one percent of the total number of salmonids in the project area. The low number of juveniles expected to be injured or killed as a result of dewatering is based on the low percentage of projects that require dewatering (i.e., generally only up to 12 percent; NMFS 2012d), the avoidance behavior of juveniles to disturbance, the small area affected during dewatering at each site, the low number of juveniles in the typically degraded habitat conditions common to proposed restoration sites, and the low numbers of juvenile salmonids expected to be present within each project site after relocation activities.

12.4.2.2 Fish Relocation Activities

All restoration sites that require dewatering will include fish relocation. CDFW personnel (or designated agents) capture and relocate fish (and amphibians) away from the restoration project work site to minimize adverse effects of dewatering to listed salmonids. Fish in the immediate project area will be captured by seine, dip net and/or by electrofishing, and will then be transported and released to a suitable instream location.

12.4.2.2.1 Exposure

Because fish relocation occurs immediately prior to or during dewatering, the life stage most likely to be exposed to fish relocation are also juvenile coho salmon.

12.4.2.2.2 Response

Fish relocation activities may injure or kill rearing juvenile coho salmon because these individuals are most likely to be present in the restoration sites. Any fish collecting gear, whether passive or active (Hayes 1983) has some associated risk to fish, including stress, disease transmission, injury, or death. The amount of injury and mortality attributable to fish capture varies widely depending on the method used, the ambient conditions, and the expertise and experience of the field crew. The effects of seining and dip-netting on juvenile salmonids include stress, scale loss, physical damage, suffocation, and desiccation. Electrofishing can kill juvenile salmonids, and researchers have found serious sublethal effects including spinal injuries (Reynolds 1983, Habera et al. 1996, Habera et al. 1999, Nielsen 1998, Nordwall 1999). The long-term effects of electrofishing on salmonids are not well understood. Although chronic effects may occur, most effects from electrofishing occur at the time of capture and handling.

Most of the stress and death from handling result from differences in water temperature between the stream and the temporary holding containers, dissolved oxygen levels, the amount of time that fish are held out of the water, and physical injury. Handling-related stress increases rapidly if water temperature exceeds 18 °C or dissolved oxygen is below saturation. A qualified fisheries biologist will relocate fish, following both CDFW and NMFS electrofishing guidelines. Because of these measures, direct effects to, and mortality of, juvenile coho salmon during capture will be greatly minimized.

Although sites selected for relocating fish will likely have similar water temperature as the capture site and should have ample habitat, in some instances relocated fish may endure short-term stress from crowding at the relocation sites. Relocated fish may also have to compete with other salmonids, which can increase competition for available resources such as food and habitat. Some of the fish at the relocation sites may choose not to remain in these areas and may move either upstream or downstream to areas that have more habitat and lower fish densities. As each fish moves, competition remains either localized to a small area or quickly diminishes as fish disperse.

Fish relocation activities are expected to minimize individual project impacts to juvenile coho salmon by removing them from restoration project sites where they would have experienced high rates of injury and mortality. Fish relocation activities are anticipated to only affect a small number of rearing juvenile coho salmon within a small stream reach at and near the restoration project site and relocation release site(s). Rearing juvenile coho salmon present in the immediate project work area will be subject to disturbance, capture, relocation, and related short-term effects. Most of the effects associated with fish relocation are anticipated to be non-lethal. However, a very low number of rearing juvenile coho salmon captured may be injured or killed. In addition, the number of fish affected by increased competition is not expected to be significant at most fish relocation sites, based upon the suspected low number of relocated fish inhabiting the small project areas.

Effects associated with fish relocation activities will be significantly minimized due to the multiple minimization measures that will be utilized, as described in the section entitled, *Measures to Minimize Injury and Mortality of Fish and Amphibian Species during Dewatering* within Part IX of the Restoration Manual (Flosi et al. 2010). NMFS expects that fish relocation activities associated with implementation of individual restoration projects will not significantly reduce the number of returning listed salmonid adults.

12.4.2.2.3 Risk

Based on the CDFW's Fisheries Restoration Grant Program (FRGP) annual monitoring reports (CDFG 2006-2012, CDFW 2013), NMFS is able to estimate the maximum number of coho salmon expected to be captured, injured, and killed each year from the dewatering and relocation activities. The CDFW monitoring reports show that the FRGP program dewaters approximately 12 percent of their funded projects (NMFS 2012d). When estimating the maximum number of coho salmon that may be captured each year, NMFS used the FRGP monitoring reports to assess the actual number of coho salmon captured, injured, and killed in the Klamath River basin (Table 12.7). NMFS used the highest percentage recorded under the FRGP program to estimate the percent of coho salmon that would be injured or killed each year. As a result, NMFS expects that up to 17 juvenile SONCC coho salmon will be captured annually, of which up to 1 may be injured or killed annually.

Table 12.7. Dewatering and fish relocation associated with CDFW's Fisheries Restoration Grant Program.

Year	Number of Klamath projects that dewatered and relocated fish	Number of dewatering occurrences	Number of coho captured	Number Injured	Number Killed
2004	2	2	0	0	0
2005	2	2	5	0	0
2006	4	4	0	0	0
2007	1	1	17	0	0
2008	3	6	10	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	0	0	0	0	0
Estimated annual maximum number for coho salmon			17	1*	
*Factoring limited data and the possibility of injuring or killing coho salmon, NMFS estimates a maximum of one coho salmon may be injured or killed per year.					

12.4.2.3 Structural Placement

Most of the proposed restoration project types include the potential for placement of structures in the stream channel. These structural placements can vary in their size and extent, depending on their restoration objective. Most structural placements are discrete where only a localized area will be affected. The salmonids exposed to such structural placements are the same juvenile species that would be exposed to dewatering effects. Where structural placements are small and discrete, salmonids are expected to avoid the active construction area and thus will not be crushed. When structural placements are large or cover a large area, such as gravel augmentation, some juvenile salmonids may be injured or killed. However, the number of juveniles injured or killed is expected to be no more than the number of individuals that will be killed by desiccation after the reach is dewatered without such structural placement. Fish relocation is expected to remove most salmonids. In essence, juvenile fish that are not relocated will be killed by either dewatering or structural placement.

12.4.2.4 Increased Mobilization of Sediment within the Stream Channel

The proposed restoration project types involve various degrees of earth disturbance. Inherent with earth disturbance is the potential to increase background suspended sediment loads for a short period during and following project completion.

All project types involving ground disturbance in or adjacent to streams are expected to increase turbidity and suspended sediment levels within the project work site and downstream areas. Therefore, instream habitat improvement, instream barrier modification for fish passage improvement, stream bank stabilization, fish passage improvements at stream crossings, small dam removal[11], creation of off channel/side channel habitat, and fish screen construction may result in increased mobilization of sediment into streams. Although riparian restoration may involve ground disturbance adjacent to streams, the magnitude and intensity of this ground disturbance is expected to be small and isolated to the riparian area. Fish screen projects are not expected to release appreciable sediment into the aquatic environment.

12.4.2.4.1 Exposure

In general, sediment-related effects are expected during the summer construction season (June 15 to November 1), as well as during peak-flow winter storm events when remaining loose sediment is mobilized. During summer construction, the species and life stages most likely to be exposed to potential effects of increased sediment mobilization are juvenile coho salmon. As loose sediment is mobilized by higher winter flows, adult coho salmon may also be exposed to increased turbidity. Removal of small dams and road crossing projects will have the greatest potential for releasing excess sediment. However, minimization measures, such as removing excess sediment from the dewatered channel prior to returning flow will limit the amount of sediment released. The increased mobilization of sediment is not likely to degrade spawning gravel because project related sediment mobilization should be minimal due to the use of sideboards and minimization measures. This small amount of sediment is expected to affect only a short distance downstream, and should be easily displaced by either higher fall/winter flows or redd building. In the winter, the high flows will carry excess fine sediment downstream to point bars and areas with slower water velocities. Because redds are built where water velocities are

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[11] Because of the sideboards and engineering requirements described in the proposed action, small dam removal is expected to have similar sediment mobilization effects as culvert replacement or removal

higher, the minimally increased sediment mobilization is not expected to smother existing redds. Therefore, salmonid eggs and alevin are not expected to be exposed to the negligible increase in sediment on redds. Since most restoration activities will focus on improving areas of poor instream habitat, NMFS expects the number of fish inhabiting individual project areas during these periods of increased sediment input, and thus directly affected by construction activities, to be relatively small.

12.4.2.4.2 Response

Restoration activities may cause temporary increases in turbidity and deposition of excess sediment may alter channel dynamics and stability (Habersack and Nachtnebel 1995, Hilderbrand et al. 1997, Powell 1997, Hilderbrand et al. 1998). Erosion and runoff during precipitation and snowmelt will increase the supply of sediment to streams. Heavy equipment operation in upland and riparian areas increases soil compaction, which can increase runoff during precipitation. High runoff can then, in turn, increase the frequency and duration of high stream flows in construction areas. Higher stream flows increase stream energy that can scour stream bottoms and transport greater sediment loads farther downstream than would otherwise occur.

Sediment may affect fish by a variety of mechanisms. High concentrations of suspended sediment can disrupt normal feeding behavior (Berg and Northcote 1985), reduce growth rates (Crouse et al. 1981), and increase plasma cortisol levels (Servizi and Martens 1992). Increased sediment deposition can fill pools and reduce the amount of cover available to fish, decreasing the survival of juveniles (Alexander and Hansen 1986) and holding habitat for adults. Excessive fine sediment can interfere with development and emergence of salmonids (Chapman 1988). Upland erosion and sediment delivery can increase substrate embeddedness. These factors make it harder for fish to excavate redds, and decreases redd aeration (Cederholm et al. 1997). High levels of fine sediment in streambeds can also reduce the abundance of food for juvenile salmonids (Cordone and Kelly 1961, Bjornn et al. 1977).

Short-term increases in turbidity are anticipated to occur during dewatering activities and/or during construction of a coffer dam. Research with salmonids has shown that high turbidity concentrations can: reduce feeding efficiency, decrease food availability, reduce dissolved oxygen in the water column, result in reduced respiratory functions, reduce tolerance to diseases, and can also cause fish mortality (Berg and Northcote 1985, Gregory and Northcote 1993, Velagic 1995, Waters 1995). Mortality of coho salmon fry can result from increased turbidity (Sigler et al. 1984). Even small pulses of turbid water will cause salmonids to disperse from established territories (Waters 1995), which can displace fish into less suitable habitat and/or increase competition and predation, decreasing chances of survival. Nevertheless, much of the research mentioned above focused on turbidity levels significantly higher than those likely to result from the proposed restoration activities, especially with implementation of the proposed avoidance and minimization measures.

Research investigating the effects of sediment concentration on fish density has routinely focused on high sediment levels. For example, Alexander and Hansen (1986) measured a 50 percent reduction in brook trout (*Salvelinus fontinalis*) density in a Michigan stream after manually increasing the sand sediment load by a factor of four. In a similar study, Bjornn et al. (1977) observed that salmonid density in an Idaho stream declined faster than available pool volume after the addition of 34.5 m^3 of fine sediment into a 165 m study section. Both studies attributed reduced fish densities to a loss of rearing habitat caused by increased sediment deposition. However, streams subject to infrequent episodes adding small volumes of sediment to the channel may not experience dramatic morphological changes (Rogers 2000). Similarly, research investigating severe physiological stress or death resulting from suspended sediment exposure has also focused on concentrations much higher than those typically found in streams subjected to minor/moderate sediment input (Newcombe and MacDonald 1991, Bozek and Young 1994).

In contrast, the lower concentrations of sediment and turbidity expected from the proposed restoration activities are unlikely to be severe enough to cause injury or death of juvenile coho salmon. Instead, the anticipated low levels of turbidity and suspended sediment resulting from instream restoration projects will likely result in only temporary behavioral effects. Monitoring of newly replaced culverts[12] in Humboldt County detailed a range in turbidity changes downstream of newly replaced culverts following winter storm events (Humboldt County 2002, 2003 and 2004). During the first winter following construction, turbidity rates (NTU) downstream of newly replaced culverts increased an average of 19 percent when compared to measurements directly above the culvert. However, the range of increases within the 11 monitored culverts was large (range of 123 percent to -21 percent; Humboldt County 2002, 2003 and 2004). Monitoring results from one- and two-year-old culverts showed much less increases in NTUs downstream of the culverts (n=11; range of 12 percent to -9 percent), with an average increase in downstream turbidity of one percent. Although the culvert monitoring results show decreasing sediment effects as projects age from year one to year three, a more important consideration is that most measurements fell within levels that were likely to only cause slight behavioral changes [e.g., increased gill flaring (Berg and Northcote 1985), elevated cough frequency (Servizi and Marten 1992), and avoidance behavior (Sigler et al. 1984)]. Turbidity levels necessary to impair feeding are likely in the 100 to 150 NTU range (Gregory and Northcote 2003, Harvey and White 2008). However, only one of the Humboldt County measurements exceeded 100 NTU (i.e., North Fork Anker Creek, year one), whereas the majority (81 percent) of downstream readings were less than 20 NTU. Importantly, proposed minimization measures, some of which were not included in the culvert work analyzed above, will likely ensure that future sediment effects from fish passage projects will be less than those discussed above.

12.4.2.4.3 Risk

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[12] When compared to other instream restoration projects (*e.g.*, bank stabilization, instream structure placement), culvert replacement/upgrade projects typically entail a higher degree of instream construction and excavation, and by extension greater sediment effects. Thus, NMFS focused on culvert projects as a “worst case” scenario when analyzing potential sediment effects from instream projects.

Small pulses of moderately turbid water expected from the proposed instream restoration projects will likely cause only minor physiological and behavioral effects, such as dispersing salmonids from established territories, potentially increasing interspecific and intraspecific competition, as well as predation risk for the small number of affected fish.

NMFS does not expect sediment effects to accumulate at downstream restoration sites within a given watershed. Sediment effects generated by each individual project will likely impact only the immediate footprint of the project site and up to approximately 1500 feet of channel downstream of the site. Studies of sediment effects from culvert construction determined that the level of sediment accumulation within the streambed returned to control levels between 358 to 1,442 meters downstream of the culvert (LaChance et al. 2008). Because of the multiple measures to minimize sediment mobilization, described in the Restoration Manual (Flosi et al. 2010) under *Measures to Minimize Degradation of Water Quality,* on pages IX-50 and IX-51, downstream sediment effects from the proposed restoration projects are expected to extend downstream for a distance consistent with the range presented by LaChance et al. (2008). The proposed 800-foot buffer between instream projects is likely large enough to preclude sediment effects from accumulating at downstream project sites. Furthermore, the temporal and spatial scale at which project activities are expected to occur will also likely preclude significant additive sediment related effects. Assuming projects will be funded and implemented similar to PacifiCorp’s coho enhancement fund in the past few years, NMFS expects that individual restoration projects sites will occur over a broad spatial scale each year. In other words, restoration projects occurring in close proximity to other projects during a given restoration season is unlikely, thus diminishing the chance that project effects would combine. Finally, effects to instream habitat and fish are expected to be short-term, since most project-related sediment will likely mobilize during the initial high-flow event the following winter season. Subsequent sediment mobilization is likely to occur following the next two winter seasons. However, suspended sediment generally should subside to baseline conditions by the third year (Klein et al. 2006, Humboldt County 2004).

12.4.2.5 Noise, Motion, and Vibration Disturbance from Heavy Equipment Operation

Noise, motion, and vibration produced by heavy equipment operation are expected at most instream restoration sites. However, the use of equipment, which will occur primarily outside the active channel, and the infrequent, short-term use of heavy equipment in the wetted channel to construct cofferdams, is expected to result in insignificant adverse effects to listed fishes. Listed salmonids will be able to avoid interaction with instream machinery by temporarily relocating either upstream or downstream into suitable habitat adjacent to the worksite. In addition, the minimum distance between instream project sites and the maximum number of instream projects under the proposed Program would further reduce the potential aggregated effects of heavy equipment disturbance on listed salmonids

12.4.2.6 Beneficial Effects to Coho Salmon

Reclamation proposes to financially support restoration actions to benefit coho salmon and its habitat. Fisheries habitat restoration projects that are funded by Reclamation will be designed and implemented consistent with the techniques and minimization measures presented in the

CDFW's Restoration Manual (Flosi et al. 2010) to maximize the benefits of each project while minimizing effects to salmonids. Most restoration projects are for the purpose of restoring degraded salmonid habitat and are intended to improve instream cover, pool habitat, spawning gravels, and flow levels; remove barriers to fish passage; and reduce or eliminate erosion and sedimentation impacts. Others prevent fish injury or death, such as diversion screening projects. Although some habitat restoration projects may fail or cause small losses to the juvenile life history stage of listed salmonids in the project areas during construction, most of these projects are anticipated to restore coho salmon habitat over the long-term.

The Restoration Manual (Flosi et al. 2010) provides design guidance and construction techniques that facilitate proper design and construction of restoration projects. As discussed earlier in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section (i.e., section 11.4.2.3), NMFS expects the habitat restoration activities will amount to an annual average of about 71 percent effectiveness.

a. Instream Habitat Improvements

In addition to the habitat benefits discussed earlier in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section (i.e., section 11.4.2.3), stream enhancement techniques aimed at reducing juvenile displacement downstream during winter floods and at providing deep pools during summer low flows could substantially increase stream rearing capacity for coho salmon (Narver 1978). Presence and abundance of LWD is correlated with growth, abundance and survival of juvenile salmonids (Fausch and Northcote 1992, Spalding et al. 1995). Weir structures can also be used to replace the need to annually build gravel push up dams. Once these weir structures are installed and working properly, construction equipment entering and modifying the channel would no longer be needed prior to the irrigation season. The benefits of reducing or eliminating equipment operation during the early spring reduces the possibility of crushing salmon redds and young salmonids.

b. Instream Barrier Modification for Fish Passage Improvement

Fish passage improvements will increase access for coho salmon adults and juveniles to previously unavailable habitat. These restoration activities will likely increase the current spatial structure of coho salmon populations. Reintroducing listed salmonids into previously unavailable upstream habitat will also likely increase reproductive success and ultimately fish population size in watersheds where the amount of quality freshwater habitat is a limiting factor.

c. Stream Bank Stabilization

In addition to the habitat benefits discussed earlier in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section (i.e., section 11.4.2.3), stream bank stabilization will reduce sediment delivery to the stream and is likely to improve coho salmon embryo and alevin survival in spawning gravels and reduce injury to juvenile coho salmon from high concentrations of suspended sediment. Successfully reducing streambank erosion will be beneficial to coho salmon because coho salmon will then be exposed to lower suspended sediment concentrations.

Boulder faces in the deflector structures have the added benefit of providing invertebrate habitat, and space between boulders provides juvenile salmonid escape cover.

d. Fish Screens

Fish screen projects will reduce the risk of fish being impinged or entrained into irrigation systems. Well-designed fish screens and associated diversions ensure that coho salmon injury or stranding is avoided, and that coho salmon are able to migrate through the stream.

12.4.2.7 Summary

Although Reclamation's funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects the suite of restoration activities will likely result in benefits to coho salmon in the action area. Based on information on the PacifiCorp's coho enhancement fund (PacifiCorp 2013), NMFS estimates approximately four to six restoration projects will be implemented each year throughout the mainstem Klamath River and major tributaries. As discussed in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section (i.e., section 11.4.2.4), NMFS expects approximately 71 percent of the four to six restoration projects implemented each year will be beneficial for juvenile growth and survival to the smolt life stage. Because of inflation, as the cost of restoration increases, the proposed $500,000 annual restoration fund will be able to fund fewer restoration projects in the latter half of the proposed action duration. The average annual rate of inflation in California between 2003 and 2012 is 2.6 percent (CA Department of Finance 2013). NMFS notes that the ecological needs of coho salmon will likely continue to be better understood, and that restoration activities are likely to become more effective at benefiting coho salmon habitat. Therefore, the increased understanding of coho salmon and habitat restoration is likely to approximately offset the effects of inflation with the result that the restoration benefits to coho salmon are likely to be reasonably similar over the 10 year proposed action period.

12.5 Cumulative Effects

Cumulative effects are those impacts of future State, Tribal, and private actions that are reasonably certain to occur within the area of the action subject to consultation. Future Federal actions will be subject to the consultation requirements established in Section 7 of the Act, and therefore are not considered cumulative to the proposed action.

NMFS believes that the SONCC coho salmon ESU may be affected by numerous future actions by State, tribal, local, or private entities that are reasonably certain to occur in, adjacent, or upslope of the action area. These activities have been discussed in the *Environmental Baseline of Coho Salmon in the Action Area* and the previous *Cumulative Effects* section (i.e., sections 12.3.3 and 11.5, respectively), and the effects of these future non-Federal actions on coho salmon are likely to be similar to those discussed in those sections.

12.6 Integration and Synthesis

The integration and synthesis is the final step of the NMFS' assessment of the risk posed to species as a result of implementing the proposed action. In this section, NMFS adds the effects of the action to the environmental baseline and the cumulative effects to formulate NMFS' biological opinion on whether the proposed action is likely to result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the status of the species.

In the *Status of the Species* section, NMFS summarized the currently high extinction risk of the SONCC coho salmon ESU. The factors that led to the listing of SONCC coho salmon ESU as a threatened species and the currently high extinction risk include past and ongoing human activities, climatological trends and ocean conditions. Beyond the continuation of the human activities affecting the species, NMFS also expects that ocean conditions and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover.

The extinction risk criteria established for the SONCC coho salmon ESU are intended to represent a species, including its constituent populations, that is able to respond to environmental changes and withstand adverse environmental conditions. Thus, when NMFS determines that a species or population has a high or moderate risk of extinction, NMFS also understands that future environmental changes could have significant consequences on the species' ability to become conserved. Also, concluding that a species has a moderate or high risk of extinction does not mean that the species has little or no potential to become viable, but that the species faces moderate to high risks from internal and external processes that can drive a species to extinction. With this understanding of the current risk of extinction of the SONCC coho salmon ESU, NMFS will analyze whether the added effects of the proposed action are likely to increase the species' extinction risk, while integrating the effects of the environmental baseline, other activities that are interdependent or interrelated with the proposed action, and cumulative effects.

All four VSP parameters for the SONCC coho salmon ESU are indicative of a species facing moderate to high risks of extinction from myriad threats. As noted previously, in order for the SONCC coho salmon ESU to be viable, all seven diversity strata that comprise the species must be viable and meet certain criteria for population representation, abundance, and diversity. Current information indicates that the species is presently vulnerable to further impacts to its abundance and productivity (Good et al. 2005, Ly and Ruddy 2011).

Known or estimated abundance of the SONCC coho salmon populations indicates most populations have relatively low abundance and are at high risk of extinction. Species diversity has declined and is influenced, in part, by the large proportion of hatchery fish that comprise the ESU. Population growth rates appear to be declining in many areas and distribution of the species has declined. Population growth rates, abundance, diversity, and distribution have been affected by both anthropogenic activities and environmental variation in the climate and ocean conditions. The species' reliance on productive ocean environments, wetter climatological conditions and a diversity of riverine habitats to bolster or buffer populations against adverse conditions may fail if those conditions occur less frequently or intensely (as is predicted) or if human activities degrade riverine habitats.

In the action area, all five populations in the Interior Klamath River stratum may be adversely affected by the proposed action. NMFS believes that the populations within the Interior Klamath River stratum have a moderate to high extinction risk. Abundance estimates indicate that all of the populations within the stratum fall below the levels needed to achieve a low risk of extinction. The large proportion of hatchery coho salmon to wild coho salmon reduces diversity and productivity of the wild species. However, due to the low demographics of the Upper Klamath and Shasta River populations, IGH coho salmon strays are currently an important component of the adult returns for these populations because of their role in increasing the likelihood that wild/natural coho salmon find a mate and successfully reproduce. Iron Gate and Trinity River Hatchery Chinook salmon smolts compete with wild coho salmon for available space and resources. Poor habitat and water quality conditions in the Shasta and Scott River basins disperse larger numbers of coho salmon fry and parr out of the Shasta and Scott basins and into the mainstem Klamath River each spring than would otherwise occur if these tributaries met the ecological needs of coho salmon (Chesney and Yokel 2003). While not restricted to the Shasta and Scott rivers, coho salmon fry and parr emigration in response to poor habitat conditions appears to affect these two populations to a greater degree than other tributary-based populations within the Klamath River Basin (NRC 2004).

In the *Environmental Baseline* section, NMFS described the current environmental conditions that influence the survival and recovery of Klamath River coho salmon populations. Coho salmon in the mainstem Klamath River will continue to be adversely affected by the ongoing activities, such as agricultural diversions and PacifiCorp's Klamath Hydroelectric Project, although PacifiCorp's Klamath Hydroelectric Project is expected to continue operating under an incidental take permit and associated HCP during most of the term of the proposed action.

There has been a recent decline in UKL outflows since the 1960s, which is likely due to increasing diversions, decreasing net inflows, or other factors (Mayer 2008). There have been declines in winter precipitation in the upper Klamath Basin in recent decades and declines in upper-Klamath Lake inflow and tributary inflow, particularly base flows (Mayer 2008). Declines in tributary base flow could be due to increase consumptive use, in particular, groundwater use, and/or climate changes. Agricultural diversions from the UKL have increased over the 1961 to 2007 period, particularly during dry years (Mayer 2008). Declines in Link River flows and Klamath River at Keno flows in the last 40-50 years have been most pronounced during the base flow season (Mayer 2008), the time when agricultural demands are the greatest.

While the operation of the PacifiCorp's dams will continue to block coho salmon access upstream of IGD and degrade water quality, PacifiCorp's HCP includes measures to minimize and mitigate these effects to the maximum extent practicable. PacifiCorp, via the HCP, committed to maintain and improve coho salmon spawning and rearing habitat in the Upper Klamath River tributaries by: (1) maintaining and improving access to existing spawning and rearing habitat in approximately 60 miles of Upper Klamath tributaries, and (2) removing existing passage barriers to create permanent access to at least one mile of potential spawning and rearing habitat in Upper Klamath tributaries. In addition, PacifiCorp will implement a turbine venting program, augment gravel and LWD downstream of IGD, target 28 cold water refugia sites along the mainstem Klamath River for improvement and maintenance of habitat complexity and cover, and fund actions that address limiting factors for coho salmon in the Shasta and Scott rivers.

NMFS expects implementation of a turbine venting program to improve habitat function by providing more suitable dissolved oxygen for juvenile summer rearing for approximately six miles downstream of IGD. NMFS also expects mainstem habitat in this reach will be improved in the next nine years, such that foraging opportunities are improved below IGD resulting in improved summer rearing and foraging habitat. Overall, the PacifiCorp HCP should decrease the extinction risk of the Upper Klamath population. Improving connectivity and increasing access to thermal refugia and productive tributary rearing and spawning sites, increasing dissolved oxygen levels below IGD, replenishing gravel and LWD at strategic locations, and diminishing disease prevalence is expected to collectively improve the survival probability for coho salmon in the Upper Klamath, Middle Klamath, Shasta, and Scott river populations.

NMFS expects many of activities discussed in the *Environmental Baseline* section will continue (e.g., timber management, habitat restoration, agricultural activities, tribal harvest). In addition, climate information indicates that the Klamath River basin is likely to experience a wide variation in hydrologic conditions (Pagano and Garen 2005), with continued warm spring periods as experienced in the last decade (Van Kirk and Naman 2008). While NMFS does not have a model to predict water temperature increases in the next 10 years, NMFS expects that recent trends of increasing water temperatures in the Klamath River basin during the summer are likely to continue. Elevated water temperatures in the tributaries and mainstem Klamath River will decrease the available thermal refugia downstream of IGD, and will increase stress, morbidity, or mortality of coho salmon juveniles.

Average annual air temperature in the upper Klamath Basin has been increasing over several decades, snow water equivalent has been declining, and both these trends are predicted to get worse. Reclamation (2011a) projected that snow water equivalent during the 2020s will decrease throughout most of the Klamath Basin, often dramatically, from values in the 1990s.

12.6.1 **Effects of the proposed action to the Interior Klamath Stratum populations**

As described in the *Effects to Individuals* section (i.e., section 12.4), the proposed action results in adverse effects to the coho salmon. Some of these adverse effects are minimized by the flow variability incorporated into the proposed action, the near real-time disease management, and the $500,000 annual restoration funding. A summary of these adverse effects and minimization measures is presented below. The coho salmon populations closest to IGD are expected to be most adversely affected. The coho salmon populations adversely affected the most to the least are the Upper Klamath, Shasta, Scott, and Middle Klamath Rivers populations. The Salmon River population is expected to have minimal adverse effects resulting from the proposed action.

Adverse effects of the proposed action to coho salmon include:

- Decreased habitat for coho salmon fry in the mainstem Klamath River from IGD (RM 190) to the Salmon River confluence (RM 66) in March to June in below average years (≥ 60 percent exceedance), and in wet years (≥ 15 percent exceedance; Table 11.9) in June;
- Decreased habitat for coho salmon juveniles in the mainstem Klamath River from IGD (RM 190) to downstream of Rogers Creek (RM 72) in March to June;
- Decreased spring flows in the mainstem Klamath River downstream of IGD and increased likelihood of consecutive drier years in the Klamath River, which will likely:
    - increase the likelihood of sub-lethal disease-related effects to coho salmon fry and juveniles while they are in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59),
    - increase the likelihood of disease-related mortality for coho salmon fry and juvenile in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May to June when environmental conditions are conducive to disease proliferation,
    - increase stress to coho salmon fry and juveniles when daily maximum water temperature become chronically above 16.5 °C in the mainstem Klamath River between IGD and Scott River (RM 143) in May to June;
- Decreased summer flows, which will also result from adaptively increasing spring flows to reduce disease risks, will likely decrease dissolved oxygen in the mainstem Klamath River below 6.0 mg/L during the summer, which will likely increase stress to coho salmon juveniles in the mainstem Klamath River between IGD (RM 190) and Orleans (RM 59) during the night and early morning;
- Using data from CDFW's Fisheries Restoration Grant Program in the Klamath River Basin, NMFS estimates that up to 17 juvenile SONCC coho salmon will be captured annually, of which up to 1 may be injured or killed annually, from fish relocation activities associated with some restoration actions. In addition, restoration actions that involve dewatering or structural placement may annually kill up to one coho salmon juvenile for each of these activities.

Like adverse effects, the coho salmon populations closest to IGD are expected to be affected the most from the flow-related minimization measures on the mainstem Klamath River. Therefore, the coho salmon populations receiving the most flow-related minimization measures on the mainstem Klamath River, in order of the greatest to the least, are the Upper Klamath, Shasta, Scott, Middle Klamath, and Salmon Rivers populations. Meanwhile, restoration activities implemented in the mainstem will benefit all coho salmon populations associated with or upstream of the restoration sites. The following measures or factors will minimize some of the adverse effects listed above:

- Flow variability incorporated into the proposed action is likely to provide increased spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin, especially during wetter water years;

- When spring flows increase, dissolved oxygen generally increases, transient habitat is increased for coho salmon fry and juveniles, and disease prevalence likely decreases because actinospore densities are expected to decrease;
- An adaptive disease management for increasing spring flows when near-real-time monitoring shows that disease thresholds have been met and EWA surplus volume is available is likely to minimize disease risks to coho salmon during average and below average water years;
- The minimum daily flows provide a limit to the disease risks posed to coho salmon under the proposed action;
- Compared to POR conditions, improved hydrologic conditions in the mainstem Klamath River (i.e., higher magnitude and frequency of channel maintenance flows and higher spring flows) will likely decrease the likelihood of *C. shasta* infections for coho salmon fry and juveniles in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) during March to June;
- The $500,000 annual restoration funding is likely to result in four to six restoration projects each year. Approximately 71 percent of the four to six restoration projects implemented each year are expected to be successful at increasing the quantity and quality of coho salmon habitat. NMFS expects the suite of restoration activities will result in long term improvements to the function and role of spawning, rearing, and migration habitat in the action area.

The proposed action's adverse effects and the minimization measures of both the Project operations and habitat restoration components of the proposed action are integrated and summarized in the table below.

Table 12.8. Summary of the proposed action's adverse effects and minimization measures.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measure(s)	Proposed Action Effects
Habitat Reduction	Increased likelihood of reduced growth or survival to some individuals	Fry	Late March to mid-June	IGD (RM 190) to Salmon River (RM 66)	Riparian and instream habitat restoration in the mainstem will likely offset some to a majority of the habitat reduction as time progresses. Riparian restoration would generally require several years of successful plant growth to effectively provide off setting effects. Instream restoration would provide more immediate benefits to fry. Successful floodplain restoration and creation of off-channel ponds will provide substantial rearing habitat for coho salmon fry, which will likely offset a majority of the habitat reduction. Water conservation projects may offset some habitat reductions. However, water conservation projects are most likely to occur in the tributaries, such as the Shasta and Scott rivers, and are not expected to reach the mainstem Klamath River. Flow variability incorporated into the proposed action will likely provide increased spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin, especially during wetter water years. Formulaic approach prioritizes EWA releases in the spring and minimum daily flow targets in April to June meet Hardy et al.'s (2006) recommended ecological base flows.	The Project will result in habitat reductions in the mainstem Klamath River. However, the minimization measures are likely to offset some of the habitat reductions, especially during above average and wetter water years when flow variability will increase flows in the mainstem Klamath River.
		Parr and Smolts	March to June	Trees of Heaven (RM 172) to Rogers Creek (RM 72)		

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measure(s)	Proposed Action Effects
Disease (*C. shasta*)	Increased likelihood of impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections	Fry	April to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)	Flow variability will increase mainstem flows when precipitation and snow melt is occurring in the Upper Klamath Basin, which will help to dilute actinospore concentrations and/or disturb polychaetes and their habitats. In addition, flow variability will provide dynamic fluvial environments in the mainstem Klamath River that may impair polychaete fitness, reproductive success, or infection with C. shasta. Compared to observed POR conditions, the Project will increase the magnitude and frequency of peak flows, which will likely decrease the abundance of polychaetes in the spring and summer following a channel maintenance flow event. In addition, the increase in magnitude and frequency of channel maintenance flows under the proposed action will likely decrease the actinospore concentrations relative to the observed POR when the channel maintenance flow event occurs in the spring, particularly in May and June. The adaptive management element of the proposed action is likely to minimize disease risks to coho salmon during average to below average water years if EWA surplus volume is available. Lastly the proposed minimum daily flows in April to June will limit the increase in disease risks posed to coho salmon under the proposed action.	The proposed action will result in disease risks to coho salmon that are lower than observed POR conditions yet higher than under natural flow conditions.
		Parr	April to August			
		Smolts	April to June			
	Increased likelihood of disease-related mortality	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)		
		Parr, and Smolts	May to June			

Potential Stressor	**Project Effects**	**Life Stage**	**General Time**	**Mainstem Location**	**Minimization Measure(s)**	**Proposed Action Effects**
Elevated water temperature	Increased stress	Fry	May to mid-June	IGD to Scott River (RM 143)	Flow variability incorporated into the proposed action will likely provide increased spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin, especially during wetter water years. Formulaic approach prioritizes EWA releases in the spring and minimum daily flow targets in April to June meet Hardy et al.'s (2006) recommended ecological base flows.	Coho salmon will continue to have increased stress from elevated water temperatures when water daily maximum temperature become chronically above 16.5 °C in May to June
		Parr and Smolts	May to June			
DO reduction	Decreased swimming performance and increased stress	Parr	June to August	IGD (RM 190) to Orleans (RM 59)	Flow variability incorporated into the proposed action will likely provide increased summer flows when precipitation and snow melt is occurring in the Upper Klamath Basin. Increases to summer mainstem flows will likely offset some DO reductions.	Coho salmon parr will continue to have decreased swimming performance or increased stress from decreased dissolved oxygen concentration in the mainstem during the late night and early morning when dissolved oxygen concentrations are below 8.0 mg/L or 6.0 mg/L, respectively.
Decreased outmigration rate	Increased likelihood of mortality from other stressors in the mainstem Klamath River (e.g., disease, predation, impaired water quality)	Smolts	April to June	IGD (RM 190) to Shasta River (RM 176)	Flow variability incorporated into the proposed action will likely provide increased spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin. Increases to mainstem flows will likely partially offset the reductions to outmigration rates.	Coho salmon smolts are likely to continue to have decreased outmigration rate in this reach, which will likely increase likelihood of decreased growth or increased mortality when environmental conditions are conducive to having increased stressors, such as increased water temperatures and disease proliferation..

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measure(s)	Proposed Action Effects
Fish relocation	Injury or mortality	Parr and smolts	June 15 to November 1	IGD (RM 190) to Salmon River (RM 66) and tributaries in action area	Compliance with CDFW's Restoration Manual, proposed construction windows, NMFS's fish screen criteria, and numerous others listed in Appendix C.	Up to 17 coho salmon juveniles may be captured each year, of which up to 1 may be injured or killed each year.
Dewatering	Mortality					Up to 1 coho salmon juvenile may be killed each year.
Structural placement						Up to 1 coho salmon juvenile may be killed each year.

12.6.2 Effects of fitness consequences on population viability parameters

12.6.2.1 Abundance

The Project will reduce spring rearing habitat availability, increase likelihood of disease prevalence, decrease outmigration rates, and will contribute to continued water quality impairments in the mainstem Klamath River in the spring and summer. However, the aggregate of the minimization measures, such as the annual habitat restoration, flow variability, minimum daily flows and adaptive management for decreasing disease risks, will minimize the adverse effects, especially during above average and wetter water years. In particular, restoration of instream and off-channel habitats will likely provide substantial quantity and/or enhanced quality of rearing habitat for coho salmon fry and juveniles in the mainstem Klamath River. In addition, water conservation and other habitat restoration activities in the tributaries will likely enhance tributary rearing habitats, which may decrease the number of coho salmon fry and parr from prematurely migrating out of the tributaries. By reducing the number of coho salmon fry and parr that prematurely enter the mainstem Klamath River, the exposure duration of these coho salmon life stages to the adverse effects in the mainstem Klamath River will be minimized.

Of all the adverse effects of the proposed action, NMFS concludes that the disease risk from *C. shasta* is the most significant to coho salmon because *C. shasta* is a key factor limiting salmon recovery in the Klamath River (Foott et al. 2009). While NMFS cannot quantify the magnitude of the increased disease risk to coho salmon under the proposed action, NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions. By lowering disease risks in a direction toward those under natural flow conditions, NMFS believes that coho salmon abundance will likely improve over the next ten years for the Upper Klamath, Middle Klamath, Shasta, and Scott river populations.

12.6.2.2 Productivity

As discussed above, NMFS estimates the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions. By lowering disease risks in a direction toward those under natural flow conditions, NMFS believes that coho salmon productivity will likely increase over the next ten years for the Upper Klamath, Middle Klamath, Shasta, and Scott river populations.

12.6.2.3 Diversity

As discussed above, the minimization measures, such as the annual habitat restoration, flow variability, minimum daily flows and adaptive management for decreasing disease risks, will offset some of the adverse effects, especially during above average and wetter water years. In particular, restoration of instream and off-channel habitats will provide substantial quantity and/or enhanced quality of rearing habitat for coho salmon fry and juveniles in the mainstem Klamath River. In addition, water conservation and other habitat restoration activities in the tributaries will likely enhance tributary rearing habitats, which may decrease the number of coho salmon fry and parr from migrating out of the tributaries. Therefore, the proposed action is not likely to result in a level of habitat reduction where coho salmon fry and juveniles in the Upper Klamath, Middle Klamath, Shasta, and Scott river populations will have reduced life history diversity.

12.6.2.4 Spatial Structure

NMFS does not expect the proposed action will reduce the spatial structure of coho salmon because the proposed action is not expected to create any physical, biological, or chemical barriers. As discussed in the *Effects to Individuals* section (i.e., sections 12.4.1.2.1 and 12.4.1.2.4.3), NMFS concurs with Reclamation's determination that the proposed action is not likely to adversely affect adult coho salmon migration in the mainstem Klamath River and does not expect the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries. In addition, the proposed habitat restoration is likely to increase coho salmon spatial structure in the action area when barriers (e.g., improperly sized culverts) are removed.

12.6.3 Summary

Of all the adverse effects of the proposed action, NMFS believes that the disease risk from *C. shasta* is the most significant to coho salmon. NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions. By lowering disease risks in a direction toward those under natural flow conditions, NMFS believes that coho salmon abundance and productivity will likely improve over the next ten years for the Upper Klamath, Middle Klamath, Shasta, and Scott river populations. NMFS believes the proposed action is not likely to result in a level of habitat reduction where coho salmon fry and juveniles in the Upper Klamath, Middle Klamath, Shasta, and Scott river populations will have reduced life history diversity. Finally, NMFS does not expect the proposed action will reduce the spatial structure of coho salmon in the action area because the proposed action is not expected to create any physical, biological, or chemical barriers.

While factoring the environmental baseline conditions of the action area, the status of the Klamath River coho salmon populations and the SONCC coho salmon ESU, and the cumulative effects, NMFS believes the proposed action is not likely to increase the extinction risk of the Upper Klamath, Shasta, Scott, Salmon, and Middle Klamath river populations. Therefore, the proposed action is not likely to increase the extinction risk of the Interior Klamath Diversity Stratum or the SONCC coho salmon ESU.

12.7 Conclusion

After considering the best available scientific and commercial information, the current status of the SONCC coho salmon ESU, the environmental baseline for the action area, the effects of the proposed action, and cumulative effects in the action area, it is NMFS' biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the SONCC coho salmon ESU.

13 INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits take of federally listed endangered wildlife without a specific permit or exemption. Protective regulations adopted pursuant to ESA section 4(d) extend this prohibition to threatened wildlife species. Take is defined by the ESA as actions that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (ESA section 3(19)). Harm is further defined by NMFS and USFWS as an act that actually kills or injures fish or wildlife (50 CFR 222.102 and 50 CFR 17.3). Such an act includes significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR 222.102 and 50 CFR 17.3). Incidental take refers to takings that results from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Under the terms of Sections 7(b)(4) and 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking, providing that such taking is compliant with this Incidental Take Statement.

For the exemption in Section 7(o)(2) to apply, the measures described below are nondiscretionary, and must be implemented by Reclamation so that they become binding conditions of any grant or permit issued to the permittee(s), as appropriate. Reclamation has a continuing duty to regulate the activity covered by this Incidental Take Statement. If Reclamation fails to assume and implement the Terms and Conditions, or fails to retain oversight to ensure compliance with these Terms and Conditions, the exemption provided in section 7(o)(2) may not apply. To monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the Services as specified in the Incidental Take Statement (50 CFR 402.14(i)(3)).

13.1 Assumptions

13.1.1 Lost River and Shortnose Suckers

In sections 8.1 and 8.2 of this BiOp, we provided several assumptions and sideboards regarding our understanding of how the proposed action would be implemented. Our analysis of effects to LRS and SNS is based on these assumptions and sideboards; therefore, both are integral to our determination of the amount of take that will likely result from implementation of the proposed action. These assumptions and sideboards should be monitored throughout the term of this BiOp to determine if they are valid; otherwise ongoing Project operations could be outside the scope of this BiOp and reinitiation of consultation could be triggered. Please refer to *Analytical Approach* (section 8.1) and *Key Assumptions for the Effects Analysis* (section 8.2) within this BiOp for a description of the assumptions and sideboards upon which our analysis is based.

13.2 Amount or Extent of Take

13.2.1 Lost River and Shortnose Suckers

Over the 10-year term of the proposed action, take of adults, juveniles, and larval LRS and/or SNS is anticipated to occur in the form of capture, kill, wound, harm, and harass. USFWS anticipates the proposed action could result in the annual incidental take of up to 363,566 listed suckers as harm, and approximately 2.04 million suckers as harassment; 99 percent of the anticipated annual incidental take would be of sucker larvae and eggs. These numbers represent USFWS' best estimate of the number of listed suckers that could be taken. The incidental take is expected to be lethal and nonlethal harm and nonlethal harassment due to entrainment into Project facilities, seasonal habitat reductions in Project reservoirs due to water diversions, sucker monitoring and required studies, and O & M activities associated with the Project, including sucker salvage. The amount of anticipated take is summarized in Table 13.1 and discussed further below.

Table 13.1 Summary of maximum annual levels of incidental take of LRS and SNS anticipated to occur as a result of the proposed action.

Cause of Take	Locations of Take	Type of Take	Life Stage Affected	Combined Maximum Annual Amount of LRS and SNS Taken
Entrainment into Project Diversions	A Canal Link River Dam Clear Lake Dam Gerber Reservoir Dam, Other Project Diversions	Harm and Harass	Larvae Juveniles Adults	349,500 larvae harmed and 1,794,000 harassed; 1,160 juveniles harmed and 82,400harassed; 12 adults harmed and 130 harassed
Seasonal Habitat Reductions Owing to Water Diversions and End-of-Season Flow Reductions	UKL, Clear Lake Gerber Reservoir Tule Lake, Lost River, and other Project Facilities (e.g. canals)	Harm and Harass	Juveniles Adults	5,000 juveniles harmed and 50,00 juveniles and adults harassed
Implementation of Conservation Measures	UKL and Tributaries Keno Reservoir Project canals	Harm and Harass	Eggs Larvae Juveniles Adults	7,500 eggs or larvae harmed and 75,000 larvae harassed; 30 juveniles harmed and 1,500 harassed; 4 adults harmed and 200 harassed
Monitoring of Adult Sucker Populations and Larval and Juvenile Entrainment[1]	UKL, Clear Lake, Gerber Reservoir, Tule Lake Sump 1A, and Keno Reservoir	Harm and Harass	Larvae Juveniles Adults	200 juveniles harmed and 20,000 harassed; 150 adults harmed and 15,000 harassed
Operation and Maintenance Activities	Project Wide	Harm or Harass	All life stages	10 total of all life stages harassed or harmed

1. Monitoring of adult sucker populations in Project reservoirs, larval entrainment monitoring at Clear Lake Dam, and age-0 juvenile monitoring at the FES are part of the monitoring requirements under the Terms and Conditions. As such, they are in addition to take occurring as a result of the proposed action.

13.2.1.1 Incidental Take Caused by Entrainment at Project Facilities

Entrainment of LRS and SNS is anticipated to occur at Reclamation's water management facilities, including: A Canal, Link River Dam, Clear Lake Dam, Gerber Reservoir Dam, Lost

River Diversion Channel, and Ady Canal. Entrainment is also anticipated to occur at privately owned pumps and gravity diversions that use Project water and therefore are part of the Project, as described in the *Environmental Baseline* and *Effects of the Action* (sections 7 and 8) of this BiOp. The amount of entrainment is expected to vary on a seasonal and yearly basis, depending upon the level of larval production in any given year and other factors. The level of take we are authorizing is based upon what is believed to be high production conditions, and thus should be close to the maximum. We have made adjustments in estimated entrainment rates based on decreases in LRS and SNS population estimates, and the assumption that entrainment is likely to be proportional to the abundance of adult suckers, as explained below.

13.2.1.2 A Canal Entrainment Estimates

Most of the entrainment take by the Project occurs at A Canal and Link River Dam spillway gates because these facilities are immediately downstream from UKL. Although the A Canal is equipped with a state-of the-art fish screen that meets USFWS criteria, up to 320,000 larvae (50 percent of the 640,000 that reach the screen) pass through the screen and are entrained into the canal every year.

We assume all of the larvae that contact the A Canal fish screen will be harassed because this will likely disrupt normal behaviors, such as feeding and predator avoidance. Additionally, most of the larvae that pass through the screen will be harmed because they are likely to die from adverse water quality, passing through pumps and being discharged onto agricultural fields, or die at the end of the irrigation season when irrigation canals are drained. However, some larvae will survive in the canals and up to 1,500 are expected to be salvaged as age-0 juveniles at the end of the irrigation season and will be moved to permanent water bodies, such as UKL, where they are more likely to survive. The number of larvae and age-0 juveniles entrained into the A Canal headworks and that subsequently pass through the screen will be highly variable annually, and will likely depend on several factors, including annual production, which can vary annually by several orders of magnitude (Simon et al. 2012).

Suckers larger than about 30 mm total length are not likely entrained into the A Canal because of the small-sized openings in the screen. We estimate that up to 50,000 age-0 juvenile suckers and 80 adults (and older juveniles) could be bypassed to the river every year, based on entrainment studies by Gutermuth et al. (2000a, b). We assume all of these suckers passing through the bypass facility will be harassed because it will likely substantially disrupt normal behaviors, such as feeding and predator avoidance. Additionally, it is reasonable to assume that a small percentage of suckers (here we assume up to 1 percent) will be harmed (e.g., become injured) in the process of moving through the A Canal by-pass facility. Thus, we assume up to 500 juveniles and 1 adult are harmed per year at the A Canal.

The above entrainment estimates were developed based on entrainment data reported by Gutermuth (2000a, b) and the analysis presented in the 2008 Klamath Project BiOp (USFWS 2008), with one modification. For this BiOp, we reduced the numbers of suckers likely to be entrained by the A Canal and Link River Dam at the outlet of UKL by 80 percent because that is the estimated amount of decline that has occurred in the total numbers of adult sucker in UKL since the late 1990s, when entrainment was last studied (Gutermuth et al. 2000a, b). It is reasonable to assume that fewer adults would result in fewer eggs, and fewer eggs would result in fewer larvae and juveniles, and therefore entrainment should be much less now than it was in the late 1990s when it was measured.

13.2.1.3 Link River Dam Entrainment Estimates

At the Link River Dam, up to 1.34 million larvae could be entrained into the spillway gates every year, based on an analysis we developed for the 2008 BiOp (USFWS 2008), and assuming entrainment had likely decreased by 80 percent because of declines in adult populations in UKL, as described above. When PacifiCorp's Habitat Conservation Plan (HCP) is finalized later in 2013, nearly all of the Link River flow will pass through the spillway gates of the dam, and consequently we assumed all of the take occurring there will be attributable to the Project. Because we do not know exactly when the HCP will be in effect, for purposes of estimating take we assume all of the take at Link River Dam over the term of the BiOp is attributable to Reclamations actions. We further assumed that 2 percent of the larvae (26,800) passing through the spillway of the Link River Dam will be harmed (USFWS 2007). This estimate is based on a review of the literature on the effects of dams on fish that have documented injuries resulting from physical strikes with objects and pressure changes associated with passing through spillways (USFWS 2007). Additionally, some mortality could occur as a result of predators attacking disoriented suckers following spillway passage, and infections resulting from nonlethal wounds incurred during spillway passage. Based on this analysis, we estimate that up to 26,800 sucker larvae could be harmed every year at the Link River Dam as a result of the proposed action.

Additionally, we estimate that up to 30,000 age-0 juveniles could be entrained at the dam every year. Of these we assume 98 percent (29, 400) are harassed and 2 percent (600) of these are likely harmed by passing through the spillway gates. In most years, the number of entrained suckers will likely be much lower because high production years are infrequent, as mentioned above.

Annual entrainment of adult suckers at the Link River Dam, once PacifiCorp's HCP is in place, is estimated to be approximately 40. Assuming that 2 percent of these are injured as a result of physical strikes with objects and pressure changes associated with passing through the spill gates, the number of adults taken by harm would be 1.

We assume all suckers passing through the Link River Dam spillway gates will be harassed because entrainment is likely to disrupt normal behaviors such as feeding and predator avoidance. Thus, we estimate up to 1.34 million larvae, 29,400 juveniles, and 40 adult suckers could be harassed annually as a result of entrainment. Maximum annual lethal take at the Link River Dam is estimated to be up to 26,800 larvae, 600 juveniles, and 1 adult, as a result of entrainment.

13.2.1.4 Entrainment at Other Project Facilities

Entrainment is also likely occurring at other Project facilities, such as at Clear Lake and Gerber Dams, Lost River Diversion Channel, and other diversions, as discussed in the *Effects of the Action* (section 8), but we lack the data to estimate take at these facilities.

Although entrainment of LRS and SNS is likely to occur at other Project diversions under the proposed action, the only facility where entrainment has been measured is at Gerber Dam, where Reclamation estimates that 250 juvenile SNS could be entrained annually (USBR 2012).

Although no entrainment estimates are available for Clear Lake Dam, we assume entrainment of larval suckers is occurring there because the dam is downstream of the Willow Creek mouth where larval suckers enter the lake. However, suckers larger than approximately 35 mm total length are not likely entrained because of the small size of the openings in the fish screen.

Entrainment rates at these facilities are likely much lower than at the Link River Dam because there are fewer reproducing adults present in these areas when compared to UKL. Therefore at these other facilities, we assumed that entrainment take would be 10 percent of that which is estimated to be occurring at the Link River Dam where entrainment was measured. The basis for that assumption is the following: (1) the combined total adult sucker populations in Clear Lake, Gerber Reservoir, Tule Lake, Keno Reservoir, and Lost River is approximately half of those in UKL; (2) larvae would be present earlier in the season and for a shorter period in Gerber Reservoir and Clear Lake in comparison to UKL because of the earlier run-off of snow-melt in the Lost River sub-basin; (3) flows from Clear Lake and Gerber Reservoir Dams are much less than at the Link River Dam when larvae are present because of the small demand for irrigation on the east side of the Project at that time; (4) flows at the Link River Dam in the spring are high due to the downstream needs of coho salmon; and (5) water quality is better in Clear Lake and Gerber Reservoir in comparison to UKL, so there would be less of an effect of water quality on entrainment rates at Clear Lake and Gerber Reservoir, as explained in the *Effects of the Action* (section 8).

Based on this, we estimate that total annual entrainment take as harm as a result of the implementation of the proposed action by all Project water-management facilities other than at the A Canal and Link River Dam equals up to 2,700 larvae, 60 juveniles, and 10 adults. The numbers of LRS and SNS annually harassed by these facilities is estimated to be up to 134,000 larvae, 3,000 juveniles, and 10 adults (Table 13.2). Note that we estimated that the numbers of adults harassed and harmed per year would be up to 10, which is the smallest number that likely could be detected.

13.2.1.5 Entrainment Estimates for the Entire Project

Based on the analysis presented above, we estimate that the total annual entrainment take of LRS and SNS at all Project diversions, as a result of implementing the proposed action, could be up to 350,672 harmed and 1.88 million harassed; most of these will be larvae (Table 13.2).

Table 13.2 Estimated annual maximum entrainment take of LRS and SNS at Project facilities as a result of implementing the proposed action.

Location and Life Stage	Harm	Harass
A Canal		
Larvae	320,000	320,000
Juveniles	500	50,000
Adults	1	80
Link River Dam		
Larvae	26,800	1,340,000
Juveniles	600	29,400
Adults	1	40
Other Project Facilities		
Larvae	2,700	134,000
Juveniles	60	3,000
Adults	10	10
Totals	350,672	1,876,530

13.2.1.6 Incidental Take Caused by Seasonal Reductions in Habitat due to Water Management and Reduced Instream Flows below Clear Lake and Gerber Reservoir Dams and in Project Canals following the Irrigation Season

In our effects analysis, we determined that annual reductions in habitat resulting from water diversions could adversely affect age-0 juvenile suckers in UKL. Due to the annual habitat reductions occurring in UKL during August and September, it is reasonable to assume age-0 juvenile suckers could be more vulnerable to predation, be swept down the lake by currents and entrained at the A Canal or Link River Dam, or be displaced into areas of poor water quality or low food abundance. Seasonal flow reductions downstream from Clear Lake, Gerber Reservoir, and in Project canals that are drained at the end of the irrigation season could also adversely affect any age-0 juvenile suckers present. Additionally, low water levels and reduced habitat availability as a result of water diversions during infrequent severe droughts could also negatively impact age 1+ juveniles and adult suckers in Clear Lake.

Most of the negative effects of the proposed action on habitat availability are unlikely to rise to the level of harm or injury, but where there are substantial decreases in the amount or quality of habitat, adverse effects would likely be greater and could be severe enough to cause injury. For example, at very low lake levels suckers confined to small areas of shallow water would likely be at an increased risk from poor water quality, predation, parasitism, and disease, and increased competition for food could reduce food availability, thus potentially lowering productivity and survival. Based on this, we estimate that up to 50,000 total LRS and SNS age-0 juveniles and adults could be harassed and 5,000 juveniles harmed each year by seasonally lower lake levels and flow reductions below dams at the end of the irrigation season across the entire Project. In any one year there are likely to be several million age-0 juvenile suckers present in UKL (Simon et al. 2012), so the estimate of the numbers of juveniles harmed is likely to be a small percentage of the total present. The numbers of age-0 juveniles present in Clear Lake and Gerber Reservoir are likely smaller because of the smaller numbers of adults present, but could number from10 to several hundred thousand per year.

13.2.1.7 Incidental Take Caused by LRS and SNS Monitoring Activities in Project Reservoirs

As a result of monitoring, of adult LRS and SNS populations in UKL and Clear Lake, some suckers are likely to be harassed and a small percentage harmed. We estimate the maximum annual take for adult suckers from monitoring would be approximately 15,000 total. We assume all of these suckers will be harassed because collection is likely to alter normal behavior substantially, such as feeding and predator avoidance, at least for a short time. Of these, we assume 1 percent (i.e., 150 total LRS and SNS) will be harmed by unavoidable injuries received during capture.

These numbers represent the maximum take that is likely to occur in any year as a result of monitoring. Actual take will likely be less because we assumed maximum capture rates based on previous studies done in these reservoirs.

Reclamation is also required to monitor take of age-0 suckers at the Fish Evaluation Station (FES) that is part of the A Canal bypass facility. The FES has been used recently to collect and count age-0 juveniles being bypassed (Korson and Kyger 2012). We estimate up to 20,000 age-0 juvenile suckers could be captured in the FES each year, and we estimate 1 percent mortality (200 per year) could occur as a result of collecting and handling the fish. We assume all of the juveniles collected will likely be harassed because collection and examination is likely to disrupt normal behaviors such as feeding and predator avoidance.

This monitoring was not proposed by Reclamation, but it is a requirement under the Terms and Conditions and thus must be implemented. The effects of the monitoring were not analyzed in the effects analysis because monitoring was not included in the proposed action. Therefore, take resulting from this monitoring will be in addition to take caused by the proposed action. It is our opinion that this take is not likely to cause jeopardy to LRS and SNS because most of the take is harassment caused by capturing the suckers. We estimated up to 200 juveniles and 150 adult suckers could be harmed as a result of annual monitoring at the FES and in Project reservoirs. Because the take of adults as a result of monitoring is spread among the major sucker populations, adverse effects are not likely to be concentrated at any one location.

1.2.1.8. Incidental Take Caused by Proposed Conservation Measures

Canal Salvage

Reclamation proposes to capture and relocate suckers found in the irrigation canals at the end of the irrigation season. Based on recent capture rates, up to 1,500 age-0 suckers could be relocated annually. Of these, we assume all will be harassed because it is likely to cause substantial disruption of normal behaviors, and 2 percent (i.e., 30 total LRS and SNS) will be harmed by unavoidable injuries received during capture and transport.

Relocation of Suckers from Lake Ewauna to UKL

Reclamation proposes to capture and relocate suckers from Lake Ewauna and move them to UKL. We estimate up to 2,000 total LRS and SNS are likely to be relocated by this effort over the term of the BiOp, with an annual average of 200 adults over the term of the BiOp. All of these fish will be harassed because it is likely to cause substantial disruption of normal behaviors. Of these, we assume 2 percent (i.e., 40 total LRS and SNS over the term of the BiOp) will be harmed by unavoidable injuries received during capture and transport.

Controlled (Captive) Propagation

Reclamation proposes to fund a USFWS-implemented controlled-propagation program for the LRS and SNS. The details of the controlled-propagation program have not been fully developed. When the details become available, the USFWS will either apply for an ESA Section 10 recovery permit for authorization of purposeful take. To implement the propagation program, we anticipate that up to 30,000 to 40,000 eggs or 50,000 to 75,000 larvae will be removed from the wild each year. The source of the eggs or larvae will likely be the Williamson River. We estimate that 10 percent (7,500) of the larvae could die.

Investigation of Flow Reductions at Link River Dam

This proposed conservation measure is not likely to result in take of suckers above that already considered because it is focused on minimizing take at the dam.

Sucker Recovery Implementation Team Involvement

Reclamation proposes to participate in the LRS and SNS Recovery Implementation Team. No specific details are available for those activities at this time, so effects to listed species will be covered with an ESA Section 10 recovery permit when sufficient details are available.

1.2.1.9. Incidental Take Caused by O & M Activities

Reclamation intends to perform various annual maintenance activities that could require sucker salvage, and this could result in annual harassment and/or harm of up to 10 total of all life stages.

13.2.2 Incidental Take Summary for LRS and SNS

In summary, we anticipate that the proposed action could result in annual take, as harm, of up to 363,565 of all LRS and SNS life stages, and up to 2.04 million of all life stages could be harassed annually (
Table 13.3). The vast majority of the take as harm (99 percent) will be larvae. Entrainment is the largest single action resulting in take.

Table 13.3 Summary of anticipated maximum annual amount of incidental take of LRS and SNS occurring as a result of the proposed action.

Form of Take	Eggs or Larvae	Larvae	Juveniles	Adults	All Life Stages Combined	Totals
Harm	7,500	349,500	6,390	165	10	363,565
Harassment	75,000	1,794,000	153,900	15,330		2,038,230

The USFWS acknowledges that the amount of incidental take of the listed suckers described above is based on limited data and numerous assumptions, and that nearly all forms of take will be impracticable to detect and measure for the following reasons: (1) to identify larval and juvenile listed suckers to species requires collecting, transporting to a lab, and x-raying the suckers to count the number of vertebrae; (2) precise quantification of the number of listed suckers entrained into Project facilities would require nearly continuous monitoring, and would itself result in considerable lethal take; (3) their cryptic coloration makes detection difficult during salvage operations; (4) the likelihood of finding injured or dead suckers in a relatively large area, such as a reservoir or canal system, is very low; and (5) a high rate of removal of injured or killed individuals by predators or scavengers is likely to occur, which also makes detection difficult. Furthermore, listed suckers will die from causes unrelated to Project operations, and thus determining the cause of death is unlikely. For example, many moribund adult suckers were collected at the Link River Dam during the die-offs of the 1990s (Gutermuth et al. 2000a, b). These suckers were likely entrained because they were either dead or dying from disease or stressed as a result of the adverse water quality documented at that time. Therefore, the number of listed suckers taken is estimated and cannot be accurately quantified. However, we have tried to be conservative in our take estimates so we would be less likely to underestimate the effect of the taking.

13.2.1 SONCC Coho Salmon ESU

13.2.1.1 Project

Over the 10-year term of the proposed action, NMFS anticipates the proposed action will result in incidental take in the form of harm to coho salmon individuals through increased disease risks, habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, and decreased smolt outmigration rates. Quantifying the amount or extent of incidental take of coho salmon in the mainstem Klamath River is difficult since the Project’s primary mechanism for affecting coho salmon is through hydrologic changes to the Klamath River discharge at IGD. Translating these hydrologic changes into definitive numbers of fish taken through habitat reductions cannot be done at this time since finding dead or impaired specimens resulting from habitat-based effects is unlikely because of the dynamic nature of riverine systems.

The physical and biological mechanisms influencing growth, predation rates and competitive interactions of coho salmon in the Klamath River are myriad and complex. For instance, predation rates within the Klamath River are likely influenced by water quantity, water quality (e.g., turbidity), and available instream habitat, as well as the relationship between predator and prey abundance and the spatial overlap between the two. Due to the inherent biological characteristics of aquatic species, such as coho salmon, the large size and variability of the Klamath River, and the operational complexities of managing Klamath River flows, quantifying individuals that may be taken incidental to the many components of the proposed action is generally not possible. In addition, incidental take of coho salmon from the increased disease risk is difficult to estimate because of the limited data on coho salmon-specific infection and mortality rates. When NMFS cannot quantify the level of incidental take, NMFS uses surrogates to estimate the amount or extent of incidental take.

For estimating incidental take from habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, decreased smolt outmigration rates, and increased disease risks, NMFS uses a hydrologic-based surrogate because water availability in the mainstem Klamath River in the spring and summer has a direct effect on these sources of incidental take. NMFS made a number of assumptions regarding water availability under the Proposed Action that are within and outside the discretion of Reclamation's actions. As a result of Reclamation's model output from the Proposed Action's formulaic approach, NMFS made assumptions regarding the shape of the annual hydrographs and then analyzed the effects of Reclamation's proposed action on coho salmon based on these assumptions. Included in those assumptions outside of Reclamation's discretion is the assumption that accretion timing, magnitude and volume from Keno Dam to IGD in the proposed action period will be consistent with the accretion timing, magnitude and volume modeled for the 1981-2011 period.

As discussed in the BiOp, NMFS identified that the proposed action will result in the incidental take of coho salmon in the mainstem Klamath River due to habitat reductions during March through June, elevated water temperatures during May to June, reductions to dissolved oxygen concentrations during June to August, decreased smolt outmigration during April to June, and increased disease risks during April to August. Since habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, decreased smolt outmigration rates, and increased disease risks are inextricably linked to flow, NMFS uses the minimum average daily flows at IGD during March to August (Table 13.4) and the calculated EWA volumes relative to the UKL Supply (Table 13.5) to measure the level of incidental take because the minimum average daily IGD flows and the annual EWA volumes are within Reclamation's discretion.

NMFS cannot predict a specific proportion of the EWA distribution that will be incrementally released during the March through August period, when NMFS anticipates incidental take of coho salmon juveniles will occur, for a number of reasons. Distribution of the EWA during the period March through September is dependent upon Williamson River flow as a hydrological indicator to determine the releases from UKL at Link River Dam. In addition, releases at Link River Dam during March through September also take into account accretions between Link River Dam and IGD, UKL fill rate, water released for flood prevention, the volume of EWA that needs to be reserved for the base flow period (June through September), and the volume of EWA already used. During the July through September period, EWA releases may be reduced if IGD maximum flow targets are anticipated to be exceeded, which results in surplus EWA stored for release in October and November. This approach produces a hydrograph that reflects real-time hydrologic conditions, while also requiring specific portions of the total EWA to be reserved for use by specific dates. Nevertheless, NMFS expects the total EWA volume relative to the UKL supply to be release at IGD by November 15 of each calendar year, as described in Table 13.5. Therefore, reinitiation of formal consultation will be necessary if: (1) the minimum daily average flows[13] for the months of March to August are not met or (2) the annual EWA volume relative to the UKL Supply is less than expected by November 15 of each calendar year.

Table 13.4 Minimum daily average flows (cfs) for Iron Gate Dam.

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
March	1,000 cfs (28.3 m^3/sec)
April	1,325 cfs (37.5 m3/sec)
May	1,175 cfs (33.3 m3/sec)
June	1,025 cfs (29.0 m3/sec)
July	900 cfs (25.5 m^3/sec)
August	900 cfs (25.5 m^3/sec)

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[13] Up to 5 percent reduction below the minimum daily average flows at IGD may occur for up to 72-hours. If such a flow reduction occurs, the resulting average flow for the month will meet or exceed the associated minimum daily average flow.

Table 13.5 Expected annual Environmental Water Account volume relative to the Upper Klamath Lake Supply.

UKL Supply (acre-ft)	EWA Volume (acre-ft)	UKL Supply (acre-ft)	EWA Volume (acre-ft)	UKL Supply (acre-ft)	EWA Volume (acre-ft)	UKL Supply (acre-ft)	EWA Volume (acre-ft)
<600,000	320,000	840,000	472,080	1,090,000	683,430	1,340,000	959,440
600,000	320,000	850,000	478,833	1,100,000	693,000	1,350,000	972,000
610,000	324,113	860,000	485,613	1,110,000	703,185	1,360,000	984,640
620,000	330,253	870,000	492,420	1,120,000	713,440	1,370,000	997,360
630,000	336,420	880,000	499,253	1,130,000	723,765	1,380,000	1,010,160
640,000	342,613	890,000	506,113	1,140,000	734,160	1,390,000	1,023,040
650,000	348,833	900,000	513,000	1,150,000	744,625	1,400,000	1,036,000
660,000	355,080	910,000	521,430	1,160,000	755,160	1,410,000	1,049,040
670,000	361,353	920,000	529,920	1,170,000	765,765	1,420,000	1,062,160
680,000	367,653	930,000	538,470	1,180,000	776,440	1,430,000	1,075,360
690,000	373,980	940,000	547,080	1,190,000	787,185	1,440,000	1,088,640
700,000	380,333	950,000	555,750	1,200,000	798,000	1,450,000	1,102,000
710,000	386,713	960,000	564,480	1,210,000	808,885	1,460,000	1,115,440
720,000	393,120	970,000	573,270	1,220,000	819,840	1,470,000	1,128,960
730,000	399,553	980,000	582,120	1,230,000	830,865	1,480,000	1,142,560
740,000	406,013	990,000	591,030	1,240,000	841,960	1,490,000	1,156,240
750,000	412,500	1,000,000	600,000	1,250,000	853,125	1,500,000	1,170,000
760,000	419,013	1,010,000	609,030	1,260,000	864,360	1,510,000	1,177,800
770,000	425,553	1,020,000	618,120	1,270,000	875,665	1,520,000	1,185,600
780,000	432,120	1,030,000	627,270	1,280,000	887,040	1,530,000	1,193,400
790,000	438,713	1,040,000	636,480	1,290,000	898,485	1,540,000	1,201,200
800,000	445,333	1,050,000	645,750	1,300,000	910,000	1,550,000	1,209,000
810,000	451,980	1,060,000	655,080	1,310,000	922,240	1,560,000	1,216,800
820,000	458,653	1,070,000	664,470	1,320,000	934,560	1,570,000	1,224,600
830,000	465,353	1,080,000	673,920	1,330,000	946,960	1,580,000	1,232,400

Specific to the increased disease risks, NMFS uses an additional surrogate to estimate incidental take of coho salmon. In contrast to coho salmon, researchers have been able to conduct a wide-range of studies associated with disease in Chinook salmon because Chinook salmon are more abundant in the Klamath River and disease monitoring of Chinook salmon has been occurring consistently since 2004. For these reasons and because coho salmon have similar susceptibility to *C. shasta* as Chinook salmon (Stone et al. 2008), NMFS uses the results of the *C. shasta* monitoring on Chinook salmon as a surrogate for estimating incidental take of coho salmon fry and juveniles resulting from Reclamation's proposed action.

NMFS has evaluated nine years of monitoring data from 2004 to 2012, and found 54 percent (via histology or 49 percent via quantitative polymerase chain reaction [QPCR]; True et al. 2013) to be the highest percentage of *C. shasta* infection rates for Chinook salmon in the mainstem between the Shasta River and the Trinity River during the months of May to July. While incidental take of coho salmon fry and juveniles from the increased disease risks may occur from

April to August, NMFS believes that estimating incidental take during May to July period is representative of the entire April to August period because May to July encompasses the peak and the majority of the *C. shasta* disease risks for coho salmon fry and juveniles. As discussed in the *Effects to Individuals* section (i.e., section 12.4), NMFS concluded that the proposed action will likely result in disease risks to coho salmon fry and juveniles that are lower than under the observed POR conditions. NMFS does not have information to specifically estimate what the reduced *C. sha*sta infection rates for salmon will be under the proposed action; however, for the reasons described in the *Effects to Individuals* section, NMFS concludes that the incidental take of coho salmon fry and juveniles will not exceed the rates observed in the POR. By using the highest percentage of *C. shasta* infection rates for Chinook salmon observed in the POR, NMFS has a secondary surrogate in addition to the March to August minimum daily average IGD flows and the EWA volumes to estimate the incidental take of coho from the increased disease risk. If the percent of *C. shasta* infections for Chinook salmon juveniles in the mainstem Klamath River between Shasta River and Trinity River during May to July exceed these levels (i.e., 54 percent infection via histology or 49 percent infection via QPCR), reinitiation of formal consultation will be necessary.

13.2.1.2 Restoration Activities

Over the 10-year term of the proposed action, NMFS expects the restoration activities funded under the proposed action will result in incidental take of SONCC ESU coho salmon juveniles. Juvenile coho salmon will be captured, harmed, injured, or killed from the dewatering, structural placement, and fish relocating activities at the restoration project sites. Based on monitoring data of similar restoration activities, NMFS expects no more than 17 juvenile SONCC ESU coho salmon will be captured annually, of which up to 1 may be injured or killed annually. In addition, no more than one coho salmon juvenile may be annually killed by dewatering and no more than one coho salmon juvenile may be annually killed by structural placement.

13.2.1.3 Incidental Take Summary for Coho Salmon

A summary of maximum amount or extent of incidental take by life history stage, stressor, and general location within the action area that is expected to occur as a result of the proposed action is presented below (Table 13.6).

Table 13.6 Summary of annual incidental take of SONCC coho salmon expected to occur as a result of the proposed action.

Cause of Incidental Take	Life Stage	General Time	Location	Type of Incidental Take	Amount or Extent of Incidental Take
Habitat Reduction	Fry	Late March to mid-June	IGD (RM 190) to Salmon River (RM 66)	Harm	Measured by a surrogate of the minimum average daily flows at IGD during March to August (Table 13.4) and the expected EWA volumes relative to UKL supply (Table 13.5).
	Parr and Smolts	March to June	Trees of Heaven (RM 172) to Rogers Creek (RM 72)		
Elevated water temperature	Fry	May to mid-June	IGD to Scott River (RM 143)		
	Parr and Smolts	May to June			
DO reduction	Parr	June to August	IGD (RM 190) to Orleans (RM 59)		
Decreased outmigration rates	Smolts	April to June	IGD (RM 190) to Shasta River (RM 176)		
Increased disease risks (*C. shasta*)	Fry	April to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)	Harm	Measured by a surrogate of the minimum average daily flows at IGD during March to August (Table 13.4) and the expected EWA volumes relative to UKL supply (Table 13.5). In addition, measured by a surrogate of up to 54 percent (via histology or 49 percent via QPCR) of the total annual Chinook salmon juveniles in the mainstem Klamath River between the Shasta River and the Trinity River may be infected with *C. shasta* during the months of May to July.
	Parr, and Smolts	April to August			
	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)		
	Parr, and Smolts	May to June			
Fish relocation	Parr and smolts	June 15 to November 1	IGD (RM 190) to Salmon River (RM 66) and tributaries in action area	Capture, wound, or killed	Up to 17 coho salmon juveniles may be captured each year, of which up to 1 may be wounded or killed each year.
Dewatering	Parr or smolt			Killed	Up to 1 coho salmon juvenile may be killed each year.
Structural placement					Up to 1 coho salmon juvenile may be killed each year.

13.3 Effect of the Take

In the accompanying biological opinions, USFWS determined that this level of anticipated take is not likely to result in jeopardy to LRS and SNS, and NMFS determined that this level of anticipated take is not likely to result in jeopardy to SONCC coho salmon ESU.

13.3.1 Reasonable and Prudent Measures (RPM)

The Services believe that the following reasonable and prudent measures and Terms and Conditions are necessary and appropriate to minimize the impacts of incidental take of LRS, SNS, and coho salmon resulting from the proposed action. To be exempt from the prohibitions of Section 9 of the ESA, Reclamation shall comply with all of the reasonable and prudent measures and Terms and Conditions listed below.

RPM 1. Reclamation shall take all necessary and appropriate actions within its authorities to minimize take of listed suckers as a result of implementing the proposed action.

RPM 2. Reclamation shall take all necessary and appropriate actions within its authorities to minimize take of coho salmon as a result of implementing the proposed action.

13.3.2 Terms and Conditions (T&C)

To be exempt from the prohibitions of Section 9 of the ESA, Reclamation must fully comply with conservation measures described as part of the proposed action (i.e., section 4.4) and the following Terms and Conditions that implement the reasonable and prudent measures described above. These Terms and Conditions are nondiscretionary.

T&C 1a. Ensure that No Unnecessary Actions are Taken that Increase Entrainment of Listed Suckers at the Link River Dam
Reclamation shall immediately coordinate with USFWS when monitoring shows that numbers of age-0 suckers in the A Canal FES are beginning to increase to their seasonal peak, which usually occurs in August or early September. This coordination will ensure that no unnecessary actions are taken that would increase entrainment at the dam. To determine when peak entrainment will occur, Reclamation shall monitor numbers of age-0 juvenile and older suckers moving through the FES as described below under section 13.4, *Entrainment Monitoring at Project Facilities*.

T&C 1b. Take Corrective Actions to Avoid Going below Minimum Elevations in Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A
At least once a week throughout the year, Reclamation shall assess projected water levels to determine if they are likely to fall below proposed minimums for Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A for that relevant time period. If conditions indicate that these reservoirs are likely to experience hydrologic conditions that would likely result in water levels going below the minimums, Reclamation shall alert the USFWS determine the most appropriate action to minimize risk to affected listed species. Reclamation’s required water-level monitoring for

Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A is described below under section 13.4, *Klamath Project Hydrology Monitoring*.

T&C 1c. Take Corrective Actions to Ensure UKL Elevations are Managed within the Scope of the Proposed Action

Threshold UKL elevations identified in *Effects of the Action on Lost River Sucker and Shortnose Sucker* (section 8) of this BiOp are not intended to serve as management targets. Instead, thresholds represent the extreme lower limits of elevations that should be observed in UKL during the term of the proposed action and that were considered and analyzed by this BiOp. Indeed, the expected outcomes of the proposed action are UKL elevations of the magnitude and variability displayed in figures 8.1 through 8.12. UKL elevations should rarely be at these end-of-month thresholds; most of the time, end-of-month elevations should be well above the thresholds. Therefore, whenever operations cause UKL elevations to trend downwards towards the thresholds, special scrutiny is required. As the spring-summer season progresses from March 1 to September 30, and as the fall-winter season progresses from October 1 to February 28, Reclamation shall monitor UKL elevations (not including those that are within 0.1 ft of flood control limits) to determine if there is a projected or realized progressive decrease in the elevation above the thresholds identified in section 8.1.3 of this BiOp. If a progressive decrease in elevations is identified, Reclamation shall determine the causative factors of this decrease and determine whether these factors are within the scope of the proposed action and the effects analyzed in this BiOp. If Reclamation determines that there are causative factors that may be outside the scope of the proposed action and this BiOp, Reclamation shall immediately consult with USFWS to adaptively manage and take corrective actions.

T&C 1d. Activate the A Canal Pumped-bypass System Annually by August 1

Beginning July 1 each year, Reclamation shall communicate weekly with USFWS via email to the Field Supervisor, or designee, to determine if it is appropriate to turn on the pump-based system of the FES; however, Reclamation shall activate the A Canal pumped-bypass system to run continuously beginning no later than August 1 every year and will continue using the pumped-bypass system until no additional age-0 suckers are observed in the FES, or until the A Canal diversions are terminated at the end of the season. Previous monitoring at the FES shows that age-0 suckers begin appearing in the FES on or around August 1 in most years.

T&C 1e. Optimize Salvage of Listed Suckers in Project Canals

Reclamation shall begin salvage of suckers in Project canals every year at the end of the irrigation season as soon as conditions allow, beginning in 2013. The purpose of this is to ensure that as many suckers as practicable are removed from the canals prior to freeze up and to reduce losses by predators. Reclamation shall work with the USFWS and appropriate irrigation districts to identify timing and conditions that will maximize the effectiveness of salvage efforts. Salvage of suckers should only occur when coordination with the USFWS and appropriate irrigation districts determine that such efforts would be effective given the circumstances present in that year. The need for salvage in individual Project canals shall be evaluated on a case-by-case basis in coordination with the USFWS and a draft annual salvage plan shall be formally submitted to USFWS by September 1 of every year for approval. We will work with Reclamation to develop an acceptable format for the annual plans. This plan shall include the location(s) that will receive salvaged individuals, as coordinated with the USFWS. Effective salvage operations are especially critical in years when there is an abundance of young suckers, so Reclamation shall consider potential production in its annual salvage plans. A variety of information, including numbers of spawners detected in the spawning runs and numbers of juveniles sampled in the FES, can be used to predict the relative magnitude of annual age-0 sucker production.

T&C 1f. Maximize Adult Listed Sucker Relocation Efforts at Lake Ewauna

Reclamation shall take necessary steps to ensure that the relocation efforts proposed for Lake Ewauna are done in a manner that maximizes the numbers of suckers relocated, minimizes risk to suckers, and is done as efficiently as possible. USFWS expects that the effort will be conducted efficiently and appropriately to maximize return for the effort by operating in the following manner:

1. Adults will be targeted using trammel nets;

2. Netting efforts will be conducted between April 1 and May 31 each year;

3. Netting efforts will be restricted to the northern part of Lake Ewauna;

4. If catch per unit effort of shortnose suckers for a two-week consecutive period is less than or equal to 0.25 suckers per net-hour Reclamation shall coordinate with USFWS to determine whether efforts for that year should be terminated;

5. If catch per unit effort of shortnose suckers during the second year of implementation is less than or equal to 0.25 suckers per net-hour Reclamation shall coordinate with USFWS to determine whether efforts should be conducted the following year; and

6. The *Fish Handling Guidelines for Salvaged and Transported Klamath Basin Suckers* protocol developed by Reclamation shall be followed when handling and transporting suckers.

T&C 1g. Ensure Reclamation Funded Activities related to Listed Suckers Support and are Consistent with the Lost River and Shortnose Recovery Program

Reclamation shall provide approximately $1.5 million annually starting in FY 2013 towards oversight and administration of the Lost River and Shortnose Sucker Recovery Program (Sucker Recovery Program). This Program will be coordinated by the USFWS-led and appointed Recovery Implementation Team (RIT). The purpose of the RIT is to implement actions identified in the 2013 Revised Recovery Plan for LRS and SNS which include recovery, monitoring, and research activities Now that the Revised Recovery Plan is complete, it is extremely important that the limited resources available for listed sucker activities be coordinated through the RIT to ensure that they are consistent with and support the plan. It is also important to have these activities coordinated through the RIT to maximize the efficiency and effectiveness of how these limited resources are used and leveraged.

Reclamation has supported various scientific investigations, monitoring activities, and recovery actions within its base budget for many years at the funding level identified above or greater.

This term and condition is requiring that these activities now support the Recovery Program and be coordinated through the RIT. Given that Reclamation proposes to dedicate resources toward this effort as part of their proposed action, and this term and condition is merely specifying as to how those resources will be used, we do not expect that this requirement will alter the basic design, location, scope, duration, or timing of the proposed action.

This funding provided by Reclamation will continue to support agreements with the U.S. Geological Survey for adult sucker monitoring in Upper Klamath Lake and Clear Lake. These ongoing monitoring efforts, and the consistency and quality of the resulting data, are essential to monitoring the progress of the Recovery Program and to assess effects of the proposed action to LRS and SNS. The RIT will make recommendations for use of remaining funds with a final decision on how the funds will be dispersed being made by the USFWS in coordination with Reclamation's Klamath Basin Area Office Manager. It is understood that overall funding and activity level associated with the RIT is expected to be maintained or exceeded but is dependent upon annual appropriations by Congress.

T&C 2a. Ensure that key elements of the Klamath River coho monitoring program are funded.
Reclamation has supported various scientific investigations, monitoring activities, and recovery actions for coho salmon within its base budget for many years. Key elements of the multi-agency (e.g., USFWS, CDFW, NMFS, USGS, and Reclamation) and tribally-funded Klamath River coho salmon monitoring and reporting programs, include mainstem Klamath River juvenile monitoring using rotary screw traps and fyke nets, fish collection for ongoing disease research, and adult salmon carcass and redd surveys. Weekly updates in real-time fashion on disease prevalence are currently updated on Arcata Fish and Wildlife Office's website. Future budget reductions could diminish the scope of key elements of Klamath River monitoring and disease research programs which collect information on the abundance, distribution and health of coho salmon. Should the existing multi-agency coho monitoring and disease research programs become reduced, Reclamation will coordinate with NMFS and other appropriate entities, to identify top priority projects that could be funded to ensure information necessary to monitor incidental take of coho salmon continues to be gathered and annually reported to NMFS, including information identifying *C. shasta* infection rates for Chinook salmon and coho salmon in the mainstem between the Shasta River and the Trinity River during May to July.

Specifically, the overall funding provided by Reclamation will be maintained or exceeded at the level of funding Reclamation has contributed to coho monitoring and disease research during recent fiscal years. Overall funding by Reclamation is also dependent upon annual appropriations by Congress.

T&C 2b. Ensure that the predictive modeling tool Stream Salmonid Simulator (S^3) is developed to support coho salmon analyses.
The S^3 Model is an integrated set of sub models that can be used to predict the effects of water management alternatives on the production of juvenile salmon. The current version of the S^3 Model tracks causes of mortality throughout the sub-adult life history of Chinook salmon (redd scour, habitat limitations, disease, water quality, etc.) over time within the 233-mile section of the mainstem Klamath River spanning from Keno Dam in Oregon to its confluence with the Pacific Ocean in California. To date, the target species for S^3 modeling has been Chinook

salmon; however, data exists to support coho salmon analyses as well. NMFS expects that a version of the S^3 model developed specifically for coho salmon using the initial physical habitat framework will enhance capabilities to evaluate the effects of Reclamation's actions on the key physical and biological factors influencing coho salmon survival and fitness in the mainstem Klamath River. Over the next five years, Reclamation will provide funds, to the extent necessary, to USFWS and USGS to support the development of a coho salmon-specific S^3 life cycle model. If within the next five years, funding levels are not available in sufficient amounts for USFWS and USGS to complete the S^3 life cycle model, Reclamation will coordinate with NMFS, and other appropriate entities, to identify available funding for coho research activities and prioritize funds to support completion of the model.

T&C 2c. Ensure accurate monitoring of hydrologic accretions.

Accretions upstream of Iron Gate Dam are an integral component of the expected flows in which NMFS analyzed the effects of Reclamation's Proposed Action. In our analysis, NMFS assumes under the proposed action period, accretion timing, magnitude and volume from Link River Dam to IGD will be consistent with those modeled for the period of record. NMFS also assumes that in the proposed action period, accretions from Link River Dam to IGD will be routed through PacifiCorp's hydroelectric reach in a manner that is consistent with the proposed action modeled results for the period of record. Ensuring accurate monitoring of accretions will provide validation for accretion estimates used in calculation of IGD flows and result in a more accurate and efficient IGD flow scheduling process. These data will also provide verification for NMFS that accretions are representative of the period of record and within the bounds of what NMFS analyzed. Better estimates and measurements of accretion data will allow the opportunity to optimize EWA by utilizing accretions to meet important flow thresholds.

Reclamation will coordinate with PacifiCorp within 6 months to collect and assemble all relevant available hydrologic accretion data between Link River Dam and IGD. Reclamation will also provide the available accretion data to NMFS by November 1, 2013 to help verify that flows at IGD are consistent with what NMFS expects to occur under the proposed action.

Terms and Conditions Implementation Agreement

To implement the above Terms and Conditions, Reclamation shall develop an *"Implementation Agreement*" in consultation with the Services describing how Reclamation intends to implement the above listed requirements. The formal *Implementation Agreement* shall describe the process Reclamation will follow to ensure necessary resources are allocated to implement the Terms and Conditions and to complete required monitoring and reporting by the due dates.

We understand that this BiOp contains multiple requirements for deliverables and that it might be infeasible for Reclamation to have all of them prepared by the stated due dates because of staffing and funding limitations; therefore, we will work with Reclamation to develop an acceptable implementation schedule. The draft *Implementation Agreement* shall be developed in consultation with the Services and provided to us for review by August 1, 2013, and a final agreement formally delivered to the Services by October 1, 2013, or at a date agreeable to the Services.

13.4 Mandatory Monitoring and Reporting Requirements under the Terms and Conditions

13.4.1 Lost River and Shortnose Suckers

When incidental take is anticipated, the Terms and Conditions must include provisions for monitoring to report the progress of the action and its impact on the listed species as specified in the Incidental Take Statement (50 CFR §402.14(i)(3)). However, monitoring the amount or extent of take of suckers due to entrainment, adverse water quality, and habitat loss as a result of the proposed action is impossible, as was described above. Therefore, taking the above findings into consideration, monitoring of the impacts of incidental take shall be conducted by Reclamation.

Monitoring shall be as described below.

1. Entrainment Monitoring at Project Facilities

Below we describe what will be required in terms of entrainment take monitoring at Project facilities.

1a. A Canal Fish Evaluation Station Entrainment Monitoring

Reclamation shall monitor entrainment of age-0 and age-1 juvenile suckers at the A Canal FES annually from August 1 to September 30. The level of effort shall be sufficient to determine when the peak of entrainment occurs and to provide an accurate estimate of the numbers of suckers entrained during the peak. An estimation of the number of juveniles moving through the bypass system during the peak period requires sufficient samples taken both within and among days.

Monitoring at the FES shall begin no later than August 1 of every year, and will continue until no additional suckers are collected in the FES in a given week, or until September 30, whichever comes first. Prior to and after the peak entrainment period, samples shall be taken at least 3 nights per week. However during the peak entrainment period, samples shall be taken at least 5 nights per week. At least three samples shall be taken per night during both periods.

Samples need to be taken at night because that is when most sucker movement occurs. All suckers in FES samples will be counted every night, and measurements (such as length, weight, and other data as coordinated with USFWS) will be collected from a representative sample. A brief summary report of numbers of suckers collected shall be provided to USFWS every week via email, no later than the close of business on each Thursday. This will provide USFWS with the opportunity to assess patterns and provide comments to Reclamation concerning any adjustments that may be implemented to avoid unnecessary entrainment. The results of the monitoring shall be included in the *Annual Monitoring Report* due to the USFWS by March 1 of every year. The report shall describe the methods, results, and recommendations to improve monitoring in coordination with USFWS to ensure appropriate analyses are performed. A draft monitoring plan shall be developed in consultation with USFWS, and shall be formally provided to USFWS for review by July 1, 2013. A final plan incorporating USFWS review comments shall be formally provided to the USFWS for approval before August 1, 2013. This expedited schedule is necessary so that FES monitoring will begin August 1, 2013.

1b. Flow Monitoring at the A Canal, and Link River, Clear Lake, and Gerber Dams as a Surrogate for Larval Sucker Entrainment Monitoring

Entrainment monitoring of larval suckers at the A Canal, and dams at Link River, Clear Lake, and Gerber Reservoir is impracticable because of difficulty in identifying sucker larvae, expense, limited and sometime difficult or dangerous access at Clear Lake and Gerber Reservoir, and human safety concerns associated with night sampling at Gerber and Clear Lake Dams. Therefore, Reclamation shall monitor flows at each dam during the larval period: Link River Dam - April 1 to July 15; Clear Lake Dam - April 1 to June 1, and Gerber Dam - April 1 to June 1. Monitoring shall begin June 15, 2013. The use of flow as a surrogate for larval entrainment is reasonable and appropriate because entrainment of suckers has been determined to be proportional to flow at two of these facilities (additional information on the flow and entrainment is found in both the *Environmental Baseline* (section 7) and *Effects of the Action* (section 8) of this BiOp; Gutermuth et al. 2000a, b). The studies that Gutermuth et al. (2000a, b) conducted at the A-Canal and Link River Dam found that the numbers of larval suckers entrained was a function of flow and that entrainment increased with increasing flow, and thus was proportional. Therefore, measurement of flow is a reasonable and appropriate surrogate for monitoring larval entrainment. The flow data, reported as acre-feet per day, shall be included in the March 1 *Annual Monitoring Report* described below, and presented as total flow through the A Canal, and the Link River, Clear Lake, and Gerber Dams. Reclamation shall know if they have exceeded authorized take of LRS and SNS larvae at these facilities when the discretionary monthly flow volumes, in acre-feet, exceeds those that occurred during the POR analyzed in this BiOp. We recognize that there are likely to be uncontrolled flow releases (“spills”) at these dams, or emergency releases, due to high lake levels and concerns for large inflow events resulting from storms. Because these events are outside of Reclamation’s discretion, any entrainment occurring during those events would not result in unauthorized take.

2. Adult LRS and SNS Monitoring in Project Reservoirs

The USFWS anticipates that the requirements of T&C1g will serve a dual purpose of providing critical data that can be used to assess the status of the LRS and SNS and information that is needed to monitor the effects of the proposed action on sucker populations. Therefore, additional adult monitoring in Project reservoirs is unnecessary.

3. Klamath Project Implementation and Hydrologic Monitoring

Reclamation shall undertake appropriate hydrologic monitoring in Project reservoirs and canals because accurate monitoring of water levels in Project reservoirs and flows through Project facilities is fundamental to our understanding of the effects of the proposed action and amount of take of LRS and SNS.

Required hydrologic monitoring includes the following:

3a. Klamath Basin Planning Model

Reclamation shall use the WRIMS 2.0 software platform, or the most recent version, for all future versions of the KBPM, including annual updates, instead of WRIMS 1.0. Reclamation shall update the software to new versions as they are published and verified. Potential use of software other than WRIMS will be evaluated in coordination with the Services.

3b. Implementation

As of mid-March 2013, Reclamation was developing one or more operations spreadsheets that will be used to implement the proposed action. The spreadsheet(s) translate the code in the KBPM and the detailed written description of the proposed action provided in Appendix 4A of Reclamation’s biological assessment (Reclamation 2012) into an operations spreadsheet(s). The operations spreadsheet(s) will bring together the input data (e.g. Williamson River flow, UKL elevations, NRCS forecasts), equations (e.g. the multiplier applied to UKL Supply to calculate EWA, fill rate ratio), and relationships (e.g. EWA is calculated before Project Supply, methods by which the Lower Klamath Lake Refuge may be delivered water) that Reclamation will use on a daily basis to implement the proposed action. Reclamation shall provide the Services with the proposed action implementation and operation spreadsheet(s) by June 1, 2013, and at least annually thereafter. Thereafter, Reclamation shall provide updates to the Services within 2 weeks of Reclamation’s acceptance and use of the updated spreadsheet(s). The Services expect a brief tutorial explaining how Reclamation uses the spreadsheet, which data may be updated, and which data should remain fixed and not be changed or updated. Thereafter, it will be the responsibility of the Services to use the spreadsheet(s). It is not Reclamation’s responsibility to continually provide updated spreadsheets or input data on a daily, weekly, or other planned schedule.

3c. Implement Gage Quality Assurance/Quality Control Procedures

Reclamation, in consultation with the Services, shall develop a draft *QA/QC Procedures Plan* for collecting, reviewing, and presenting Project reservoir elevation, flow, diversion, and pumping data. The draft plan shall be completed and formally submitted for the Services’ review and approval by October 1, 2013. A final QA/QC plan shall be completed and formally submitted to the Services by December 1, 2013, and implementation shall begin January 1, 2014. Quality assurance shall fully describe current measurement locations and equipment, gage (or other appropriate measurement device) maintenance and installation, pump-rating curves, and data collection procedures for measuring water use within the Project. Quality control shall describe procedures for review, correction (as needed), and finalizing datasets, including a schedule for completion of QA/QC and providing the data to stakeholders. An annual summary of QA/QC compliance shall be included in the annual monitoring report due March 1 every year.

3d. Monitor and Maintain Water-Level and Flow-Measurement Gages throughout the Project

Water level and flow measurement gages shall be maintained throughout the Project in accordance with the *QA/QC Procedures Plan* developed under 3c. Water levels in Project reservoirs shall be monitored at frequent intervals, at least daily, and Reclamation shall make those data available to the Services via a secure website or other appropriate means. An annual summary of reservoir water level and flow-monitoring compliance shall be included in the *Annual Monitoring Report* due March 1 every year.

Locations within the Project where accurate hydrologic data are needed include those listed below. These locations are needed to calculate Project water use and effects on listed suckers, and ensure compliance with this Incidental Take Statement. This list shall be evaluated annually and could include additional monitoring sites if needed.

1. A Canal
2. Lost River to Lost River Diversion Channel at Wilson Dam
3. Ady Canal (at the point of common diversion for agriculture and the Lower Klamath Lake NWR, and at the point of entry into the Refuge)
4. North Canal
5. Straits Drain at State Line and at pumps F and FF
6. West Side Power Canal
7. Station 48
8. Miller Hill Pumping Plant
9. Miller Hill spill
10. UKL, Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A

3e. Annual Identification and Installation of Needed Water-Level and Flow-Measurement Gages in the Project

Reclamation shall consult with Service hydrologists and other appropriate agencies (e.g., USGS, Oregon Department of Water Resources, PacifiCorp, and irrigation districts) to assess the need for additional gages in the Project area, at least annually, beginning July 1, 2013. If new or replacement gages are deemed necessary, Reclamation shall take appropriate actions to acquire and install the gages and incorporate them into the QA/QC network as quickly as possible. An annual summary of progress on identification and installation of needed gages shall be included in the *Annual Monitoring Report* due every March 1st.

13.4.2 Monitoring Summary

A table summarizing the LRS and SNS Terms and Conditions monitoring plan development and implementation schedule, and annual monitoring report due date, is shown below in Table 13.77. As summary of monitoring plan development is present in Table 13.88.

Table 13.7. Summary of LRS and SNS Terms and Conditions monitoring plan development and implementation schedule, and annual monitoring report due date.

T&C Monitoring Number	Title of Monitoring Requirement	Date of Draft Monitoring Plan	Date of Final Monitoring Plan	Implementation Date	Annual Monitoring Report Due Date
1a	A Canal Fish Evaluation Station Monitoring	Draft plan due July 1, 2013	August 1, 2013	Begin August 1, 2013 and continue to March 31, 2023	March 1
1b	Flow Monitoring at A Canal, and Link River, Clear Lake, and Gerber Dams as a Surrogate for Larval Sucker Entrainment Monitoring	None required	None required	Begin June 15, 2013 and continue to March 31, 2023	March 1
3c	Implement Gage QA/QC control procedures	Draft QA/QC procedures plan due October 1, 2013	Final QA/QC Procedures Plan due December 1, 2013	Begin January 1, 2014 and continue to March 31, 2023	March 1
3d	Maintain Water- level and Flow-measurement Gages throughout the Project	None required	None required	As soon as BiOp is received	March 1
3e	Annual Identification and Installation of needed Water-level and Flow-measurement Gages in the Project	None required	None required	July 1, 2013	March 1

Table 13.8 Schedule Summary for LRS and SNS Term and Conditions, Mandatory Monitoring, and Reporting Requirements.

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
T&C 1b	Assess Water Levels at Project Facilities at Clear Lake, Gerber Reservoir, and Tule Lake			Weekly			Assess water levels at, Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A. Convene meeting with USFWS immediately if projected to reach minimums.
T&C 1d	Activate A Canal Pumped-bypass System	No later than August 1		Annually			Consult weekly with USFWS to determine if appropriate to turn on pump-based system of the FES. Activate to run continuously **no later than August 1** and continue until no age-0 suckers are observed or until the A Canal diversions are terminated.
T&C 1e	Optimize Salvage of Suckers in Project Canals			Annually	September 1	November 1	Starting **in 2013**, begin salvage as early as soon as conditions allow.
T&C 1f	Maximize Adult Listed Sucker Relocation Efforts at Lake Ewauna	April 1	May 31	Annually			Work efficiently to maximize sucker relocation efforts while minimizing risks to suckers.
Mandatory Monitoring 1a	A Canal Fish Evaluation Station Entrainment Monitoring	August 1	September 30	3 to 5 nights/ week	July 1, 2013	March 1	Begin August 1, 2013 and continue to March 31, 2023
Mandatory Monitoring 1b .	Flow Monitoring at A Canal, and Link River, Clear Lake, and Gerber Dams as a Surrogate for Larval Sucker Entrainment Monitoring	April 1	July 15	Annually	N/A	N/A	**Begin June 15, 2013**.

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
Mandatory Monitoring 2	Adult LRS and SNS Monitoring in Project Reservoirs						The USFWS anticipates that the requirements of T&C1g will serve this monitoring function.
Mandatory Monitoring 3b	Implementation and Operations Spreadsheet	June 1, 2013		Annually			Provide Service with annual updates to operations spreadsheet that will be used to implement the proposed action
Mandatory Monitoring 3c	Implement Gage Quality Assurance/Quality Control Procedures				October 1, 2013	December 1, 2013	**Begin implementation January 1, 2014**.
Mandatory Monitoring 3d	Gage Maintenance and Verify Accuracy			At least Annually			**Begin upon receipt of BiOp**. Ten locations require accurate data and those locations should be evaluated annually for accuracy.
Mandatory Monitoring 3d	Monitor Water Levels in Major Project Reservoirs			Daily			Make available to Services via secure website or other appropriate means.
Mandatory Monitoring 3e	Annual Identification and Installation of needed Water-level and Flow- measurement Gages in the Project	July 1, 2013		Annually		March 1	An annual summary of progress on identification and installation of needed gages shall be included in the *Annual Monitoring Report.*

13.4.3 SONCC Coho Salmon ESU

When incidental take is anticipated, the terms and conditions must include provisions for monitoring to report the progress of the action and its impact on the listed species as specified in the Incidental Take Statement (50 CFR §402.14(i)(3)). However, monitoring the amount or extent of incidental take of coho salmon due to increased disease risks, habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, and decreased smolt outmigration rates, as a result of the proposed action is impossible as described earlier. Therefore, taking the above findings into consideration, monitoring of the impacts of incidental take shall be conducted by Reclamation.

1. Reclamation will ensure (1) the annual monitoring of the percent of *C. shasta* infection rates for Chinook salmon in the mainstem between the Shasta River and the Trinity River during the months of May to July, and (2) the weekly monitoring of actinospore genotype II concentrations in the mainstem Klamath River immediately upstream of Beaver Creek during mid-April to June.
2. Reclamation will annually monitor the number of restoration projects requiring dewatering, structural placement, or fish relocation. In addition, Reclamation will monitor the total number of coho salmon captured, relocated, injured, and killed for each restoration project.

13.5 Reporting Requirements

As part of meeting the reporting requirements of this Incidental Take Statement, Reclamation shall provide the Services with an *Annual Monitoring Report* due March 1st every year and organize quarterly coordination meetings, for discussing progress on implementing the Terms and Conditions and associated monitoring requirements of this BiOp. To implement this requirement, Reclamation shall consult with the Services to develop a format for the *Annual Monitoring Report* that will be effective and efficient. The draft reporting format shall be developed by October 1, 2013, and presented to the Services for review, with a final format prepared by December 1, 2013. The first quarterly coordination meeting shall be organized by Reclamation to be held on a date in early September 2013 that is agreeable to the USFWS. The first *Annual Monitoring Report* shall be due March 1, 2014.

The quarterly coordination meetings and the annual report shall include a description of actions Reclamation has taken and is preparing to take to be compliant with this BiOp. The coordination meetings and annual reports shall include: (1) Progress on implementation of the Environmental Water Account, (2) progress on implementation of the Terms and Conditions and associated monitoring, (3) progress on budgeting for implementation of the Terms and Conditions, and (4) progress on implementing the conservation measures that were included in the proposed action. Additionally, in the first quarter of each year, Reclamation shall convene annual ESA compliance meetings with USFWS and NMFS to describe and discuss BiOp compliance and incidental take monitoring. A summary necessary communications is found below in Table 13.9. A summary of coordination meetings related to Term and Conditions monitoring requirements is found below in Table 13.10.

Table 13.9 Summary of reporting and other communication requirements necessary to implement Terms and Conditions, and meet reporting requirements associated with Incidental Take and Term and Condition Monitoring.

Title of Requirement	Requirement Reference	Required Components	Due Date	Notes
Annual Monitoring Report	Section 13.4.3 Reporting Requirements	(1)Progress on implementation of EWA; (2)Progress on implementation of T&Cs; (3)Progress on budgeting for implementation of T&Cs; (4)Progress on implementation of Conservation Measures	March 1	Develop acceptable format in coordination with USFWS no later than October 1, 2013 First report due **March 1, 2014**.
	Monitoring and Reporting Requirement 1.1b	Flow data, reported as acre-feet per day through A-Canal and Link River Dam		Included in body of annual monitoring report. Additional technical requirements included in text.
	Monitoring and Reporting Requirement 3.3c	Summary of QA/QC compliance		Included in body of annual monitoring report. Additional technical requirements included in text.
	Monitoring and Reporting Requirement 3.3d	Summary of reservoir water level and flow monitoring compliance		Included in body of annual monitoring report. Additional technical requirements included in text.
	Monitoring and Reporting Requirement 3.3e	Summary of progress on identification and installation of needed gages		Included in body of annual monitoring report. Additional technical requirements included in text.
A Canal FES Monitoring Annual Report	Monitoring and Reporting Requirement 1.1a	Methods, results, and recommendations to improve monitoring	March 1	Additional technical requirements included in text. The USFWS agreed that the A Canal FES Monitoring Annual Report would be a component of the overarching Annual Monitoring Report.

Title of Requirement	**Requirement Reference**	**Required Components**	**Due Date**	**Notes**
Term and Condition Implementation Agreement	Section 13.3.2 Terms and Conditions	Describe the process Reclamation will follow to ensure necessary resources are allocated to implement the Terms and Conditions and to complete required monitoring and reporting by the due dates.	October 1, 2013	Develop in coordination with the Services. First draft due by **July 1, 2013**. Date of final submission can be at a date agreeable to the Services.

Table 13.10 Summary of meetings required to implement Term and Conditions, monitor incidental take, and meet associated reporting requirements.

Meeting Title	Requirement Reference	Required Components	Due Date	Tentative Meeting Date
Annual ESA Compliance Meeting	Section 13.4.3 Reporting Requirements	Describe and discuss BiOp compliance and incidental take monitoring	April 15	Rotate location of meeting as follows: 1 year Klamath Falls, OR 1 year Arcata, CA 1 year Midpoint: Medford, OR or Redding, CA First meeting tentatively scheduled for **April 1, 2014 in Arcata**
Quarterly Meetings	Section 13.4.3 Reporting Requirements	(1) Progress on implementation of EWA (2) Progress on implementation of T&Cs (3) Progress on budgeting for implementation of T&Cs (4) Progress on implementation of Conservation Measures	March 15 June 15 Sept 15 Dec 15	First meeting tentatively scheduled for **September 2, 2013 at 2:00pm** at the USFWS Klamath Falls Office

13.5.1 Lost River and Shortnose Suckers

Upon locating a dead, injured, or sick endangered or threatened species specimen, prompt notification must be made to the nearest USFWS Law Enforcement Office (Wilsonville, Oregon; telephone: 503-682-6131) and the Klamath Falls Fish and Wildlife Office (Klamath Falls, Oregon; telephone: 541-885-8481). Care should be taken in handling sick or injured specimens to ensure effective treatment and care or the handling of dead specimens to preserve biological material in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

The Annual Incidental Take and Term and Condition Monitoring Report shall be submitted to the Field Supervisor of the USFWS's Klamath Falls Fish and Wildlife Office by March 1st every year through March 2024.

13.5.2 SONCC Coho Salmon ESU

1. Reclamation will report all measured accretion data (Link River Dam to Keno Dam) and all measured and estimated accretion data (Keno Dam to IGD) in addition to all of the EWA, Project and Refuge information in the weekly update report described in Reclamation's BA.

2. In addition to the Spring/Summer EWA management weekly report, Reclamation will provide a weekly update report for the formulaic approach during the fall/winter operations including Williamson River flow, Link River Dam to IGD accretions, UKL levels, winter Project deliveries, Refuge deliveries, and any other relevant data NMFS identifies under implementation of the proposed action.

3. Reclamation will provide rolling weekly graphs of the observed Williamson River flows and observed IGD flows versus the one and two week forecasted IGD flow schedules for the entire water year.

4. Reclamation will provide all these weekly reports and information on daily Project deliveries listed in items 1 to 3 above onto Reclamation's Klamath Basin Area Office website.

5. By March 1 of the following year, Reclamation will provide an annual report on (1) the percent of *C. shasta* infection rates for Chinook salmon in the mainstem between the Shasta River and the Trinity River during the months of May to July, and (2) the weekly actinospore genotype II concentrations in the mainstem Klamath River immediately upstream of Beaver Creek during mid-April to June.

6. Reclamation will provide an annual report on the type and location of each restoration project. The monitoring report will include the total number of coho salmon captured, relocated, injured, or killed for each restoration project, and will be submitted annually by March 1 to the NMFS Northern California office:

National Marine Fisheries Service
Northern California Office Supervisor
1655 Heindon Road
Arcata, California 95521

7. All coho salmon mortalities must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NMFS.

13.6 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize 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 suggested to minimize or avoid adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to help implement recovery plans, or to develop additional information.

The Services make the following recommendations:

13.7 USFWS Recommendations

1. Reclamation should develop a Klamath Project Water Operations Manual, describing the annual water management of the three primary reservoirs, including details of KBPM modeling and EWA management, and operations at Tule Lake. The operations manual should also include

the above QA/QC procedures described above under *Maintain Water Level and Flow Gages Throughout the Project.* We recommend that Reclamation post the final datasets on a secure website available to stakeholders.

2. USFWS recognizes that a substantial amount of resources is committed to the gathering and analysis of sucker-related data. Therefore, it is important to ensure that such data are used as effectively as possible for the conservation of these species to minimize duplication of effort and ensure rigorous analysis. Therefore, we recommend that all data collected or funded by Reclamation as part of these monitoring efforts or other sucker-related research should be made available to USFWS when the reports are published or no later than 1 year after collection of the data if no reports are to be produced. When contracting for these efforts, Reclamation should therefore contract for the data in addition to any analyses or reports. In other words, the cleaned data and reports should be identified as deliverables in the contract.

3. A substantial effort was made by the Klamath Tribes to collect plankton samples from UKL. Those data could be highly important for understanding how plankton populations, which are the basis of the food web, are affected by lake management and other conditions in the lake. Consequently, we recommend that Reclamation provide assistance to the Klamath Tribes so that the plankton data are analyzed and a report produced.

13.8 NMFS Recommendation

1. Short-term and long-term climate change may affect and change hydrological patterns in the Klamath Basin. As a result of these potential changes, key assumptions of the WRIMS modeling results that NMFS used in this BiOp may be affected. Reclamation, in coordination with OWRD and CDFW, should assess throughout the duration of its proposed action the potential impacts of climate change in the Klamath Basin and whether the WRIMS modeling results continue to be valid.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

14 REINITIATION NOTICE

This concludes formal consultation on the actions described for the Project. 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 that may affect listed species or 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, any operations causing such take must cease pending reinitiation.

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16 APPENDICIES

16.1 Appendix A: Proposed Action UKL Elevation-Capacity Data

UKL Elevation (feet)	Active Storage (acre-feet)
4136.00	0
4136.01	463
4136.02	927
4136.03	1,392
4136.04	1,857
4136.05	2,324
4136.06	2,793
4136.07	3,263
4136.08	3,734
4136.09	4,206
4136.10	4,679
4136.11	5,153
4136.12	5,629
4136.13	6,106
4136.14	6,584
4136.15	7,063
4136.16	7,543
4136.17	8,024
4136.18	8,507
4136.19	8,992
4136.20	9,477
4136.21	9,963
4136.22	10,450
4136.23	10,939
4136.24	11,429
4136.25	11,921
4136.26	12,413
4136.27	12,906
4136.28	13,402
4136.29	13,898
4136.30	14,395
4136.31	14,893
4136.32	15,393
4136.33	15,893
4136.34	16,396
4136.35	16,899
4136.36	17,403
4136.37	17,910
4136.38	18,417
4136.39	18,926
4136.40	19,436
4136.41	19,948
4136.42	20,460
4136.43	20,975
4136.44	21,490
4136.45	22,007
4136.46	22,526
4136.47	23,045
4136.48	23,566
4136.49	24,088
4136.50	24,612
4136.51	25,137
4136.52	25,663
4136.53	26,191
4136.54	26,720
4136.55	27,251
4136.56	27,782
4136.57	28,315
4136.58	28,850
4136.59	29,386
4136.60	29,923
4136.61	30,462
4136.62	31,002
4136.63	31,542
4136.64	32,084
4136.65	32,628
4136.66	33,173
4136.67	33,719
4136.68	34,266
4136.69	34,814
4136.70	35,364
4136.71	35,915
4136.72	36,467
4136.73	37,021
4136.74	37,575
4136.75	38,130
4136.76	38,686
4136.77	39,243
4136.78	39,801
4136.79	40,361
4136.80	40,922
4136.81	41,484
4136.82	42,047
4136.83	42,612
4136.84	43,177
4136.85	43,743
4136.86	44,311
4136.87	44,878
4136.88	45,446
4136.89	46,016
4136.90	46,586
4136.91	47,158
4136.92	47,730
4136.93	48,304
4136.94	48,878
4136.95	49,454
4136.96	50,030
4136.97	50,608
4136.98	51,186
4136.99	51,766
4137.00	52,347
4137.01	52,928
4137.02	53,511
4137.03	54,095
4137.04	54,679
4137.05	55,265
4137.06	55,851
4137.07	56,437
4137.08	57,025
4137.09	57,614
4137.10	58,204

UKL Elevation (feet)	Active Storage (acre-feet)
4137.11	58,795
4137.12	59,386
4137.13	59,979
4137.14	60,573
4137.15	61,167
4137.16	61,762
4137.17	62,358
4137.18	62,955
4137.19	63,553
4137.20	64,152
4137.21	64,751
4137.22	65,351
4137.23	65,952
4137.24	66,554
4137.25	67,156
4137.26	67,759
4137.27	68,364
4137.28	68,969
4137.29	69,575
4137.30	70,181
4137.31	70,788
4137.32	71,397
4137.33	72,005
4137.34	72,614
4137.35	73,224
4137.36	73,836
4137.37	74,447
4137.38	75,059
4137.39	75,673
4137.40	76,286
4137.41	76,900
4137.42	77,515
4137.43	78,130
4137.44	78,747
4137.45	79,363
4137.46	79,981
4137.47	80,598

UKL Elevation (feet)	Active Storage (acre-feet)
4137.48	81,217
4137.49	81,836
4137.50	82,456
4137.51	83,077
4137.52	83,697
4137.53	84,319
4137.54	84,942
4137.55	85,565
4137.56	86,189
4137.57	86,813
4137.58	87,438
4137.59	88,064
4137.60	88,690
4137.61	89,318
4137.62	89,945
4137.63	90,573
4137.64	91,203
4137.65	91,832
4137.66	92,463
4137.67	93,094
4137.68	93,725
4137.69	94,358
4137.70	94,991
4137.71	95,625
4137.72	96,259
4137.73	96,894
4137.74	97,530
4137.75	98,166
4137.76	98,804
4137.77	99,441
4137.78	100,079
4137.79	100,718
4137.80	101,357
4137.81	101,998
4137.82	102,638
4137.83	103,280
4137.84	103,922

UKL Elevation (feet)	Active Storage (acre-feet)
4137.85	104,565
4137.86	105,209
4137.87	105,853
4137.88	106,498
4137.89	107,143
4137.90	107,789
4137.91	108,435
4137.92	109,082
4137.93	109,730
4137.94	110,378
4137.95	111,027
4137.96	111,677
4137.97	112,328
4137.98	112,978
4137.99	113,630
4138.00	114,282
4138.01	114,936
4138.02	115,590
4138.03	116,246
4138.04	116,901
4138.05	117,557
4138.06	118,213
4138.07	118,870
4138.08	119,528
4138.09	120,187
4138.10	120,845
4138.11	121,505
4138.12	122,164
4138.13	122,826
4138.14	123,487
4138.15	124,148
4138.16	124,810
4138.17	125,473
4138.18	126,137
4138.19	126,801
4138.20	127,465
4138.21	128,130

UKL Elevation (feet)	Active Storage (acre-feet)
4138.22	128,796
4138.23	129,464
4138.24	130,131
4138.25	130,798
4138.26	131,466
4138.27	132,134
4138.28	132,804
4138.29	133,472
4138.30	134,142
4138.31	134,812
4138.32	135,483
4138.33	136,155
4138.34	136,826
4138.35	137,497
4138.36	138,169
4138.37	138,841
4138.38	139,514
4138.39	140,186
4138.40	140,860
4138.41	141,533
4138.42	142,208
4138.43	142,881
4138.44	143,555
4138.45	144,229
4138.46	144,904
4138.47	145,580
4138.48	146,255
4138.49	146,930
4138.50	147,606
4138.51	148,282
4138.52	148,959
4138.53	149,635
4138.54	150,312
4138.55	150,989
4138.56	151,667
4138.57	152,345
4138.58	153,023
4138.59	153,701
4138.60	154,379
4138.61	155,057
4138.62	155,738
4138.63	156,417
4138.64	157,096
4138.65	157,775
4138.66	158,456
4138.67	159,137
4138.68	159,818
4138.69	160,498
4138.70	161,179
4138.71	161,861
4138.72	162,544
4138.73	163,226
4138.74	163,908
4138.75	164,590
4138.76	165,273
4138.77	165,958
4138.78	166,641
4138.79	167,325
4138.80	168,008
4138.81	168,693
4138.82	169,379
4138.83	170,064
4138.84	170,748
4138.85	171,434
4138.86	172,120
4138.87	172,807
4138.88	173,493
4138.89	174,180
4138.90	174,866
4138.91	175,554
4138.92	176,242
4138.93	176,930
4138.94	177,618
4138.95	178,306
4138.96	178,994
4138.97	179,684
4138.98	180,373
4138.99	181,062
4139.00	181,752
4139.01	182,445
4139.02	183,140
4139.03	183,834
4139.04	184,529
4139.05	185,224
4139.06	185,919
4139.07	186,614
4139.08	187,309
4139.09	188,005
4139.10	188,701
4139.11	189,397
4139.12	190,094
4139.13	190,790
4139.14	191,487
4139.15	192,184
4139.16	192,880
4139.17	193,579
4139.18	194,277
4139.19	194,975
4139.20	195,673
4139.21	196,382
4139.22	197,093
4139.23	197,802
4139.24	198,512
4139.25	199,221
4139.26	199,933
4139.27	200,643
4139.28	201,354
4139.29	202,065
4139.30	202,777
4139.31	203,488
4139.32	204,199

UKL Elevation (feet)	Active Storage (acre-feet)
4139.33	204,911
4139.34	205,623
4139.35	206,334
4139.36	207,046
4139.37	207,757
4139.38	208,470
4139.39	209,182
4139.40	209,894
4139.41	210,608
4139.42	211,321
4139.43	212,034
4139.44	212,747
4139.45	213,461
4139.46	214,175
4139.47	214,888
4139.48	215,602
4139.49	216,316
4139.50	217,030
4139.51	217,744
4139.52	218,458
4139.53	219,173
4139.54	219,887
4139.55	220,601
4139.56	221,315
4139.57	222,030
4139.58	222,745
4139.59	223,459
4139.60	224,174
4139.61	224,890
4139.62	225,606
4139.63	226,322
4139.64	227,039
4139.65	227,754
4139.66	228,470
4139.67	229,187
4139.68	229,904
4139.69	230,620
4139.70	231,336
4139.71	232,053
4139.72	232,770
4139.73	233,487
4139.74	234,203
4139.75	234,920
4139.76	235,638
4139.77	236,355
4139.78	237,071
4139.79	237,788
4139.80	238,507
4139.81	239,224
4139.82	239,941
4139.83	240,658
4139.84	241,377
4139.85	242,095
4139.86	242,814
4139.87	243,532
4139.88	244,252
4139.89	244,971
4139.90	245,690
4139.91	246,410
4139.92	247,129
4139.93	247,848
4139.94	248,567
4139.95	249,287
4139.96	250,007
4139.97	250,726
4139.98	251,446
4139.99	252,166
4140.00	252,886
4140.01	253,622
4140.02	254,360
4140.03	255,097
4140.04	255,834
4140.05	256,572
4140.06	257,309
4140.07	258,047
4140.08	258,785
4140.09	259,522
4140.10	260,260
4140.11	260,998
4140.12	261,736
4140.13	262,473
4140.14	263,212
4140.15	263,950
4140.16	264,690
4140.17	265,429
4140.18	266,168
4140.19	266,908
4140.20	267,647
4140.21	268,387
4140.22	269,127
4140.23	269,867
4140.24	270,606
4140.25	271,347
4140.26	272,086
4140.27	272,826
4140.28	273,567
4140.29	274,307
4140.30	275,047
4140.31	275,788
4140.32	276,528
4140.33	277,270
4140.34	278,010
4140.35	278,750
4140.36	279,492
4140.37	280,232
4140.38	280,973
4140.39	281,715
4140.40	282,456
4140.41	283,196
4140.42	283,938
4140.43	284,679

UKL Elevation (feet)	Active Storage (acre-feet)
4140.44	285,421
4140.45	286,163
4140.46	286,904
4140.47	287,646
4140.48	288,388
4140.49	289,129
4140.50	289,872
4140.51	290,614
4140.52	291,355
4140.53	292,098
4140.54	292,840
4140.55	293,582
4140.56	294,325
4140.57	295,067
4140.58	295,810
4140.59	296,554
4140.60	297,297
4140.61	298,040
4140.62	298,784
4140.63	299,528
4140.64	300,272
4140.65	301,016
4140.66	301,759
4140.67	302,504
4140.68	303,247
4140.69	303,991
4140.70	304,736
4140.71	305,480
4140.72	306,224
4140.73	306,968
4140.74	307,712
4140.75	308,457
4140.76	309,202
4140.77	309,946
4140.78	310,690
4140.79	311,435
4140.80	312,180
4140.81	312,925
4140.82	313,669
4140.83	314,414
4140.84	315,160
4140.85	315,904
4140.86	316,649
4140.87	317,395
4140.88	318,139
4140.89	318,884
4140.90	319,630
4140.91	320,375
4140.92	321,120
4140.93	321,866
4140.94	322,612
4140.95	323,357
4140.96	324,103
4140.97	324,848
4140.98	325,595
4140.99	326,340
4141.00	327,086
4141.01	327,874
4141.02	328,662
4141.03	329,451
4141.04	330,238
4141.05	331,027
4141.06	331,815
4141.07	332,604
4141.08	333,392
4141.09	334,181
4141.10	334,969
4141.11	335,758
4141.12	336,546
4141.13	337,336
4141.14	338,124
4141.15	338,913
4141.16	339,702
4141.17	340,491
4141.18	341,280
4141.19	342,069
4141.20	342,858
4141.21	343,648
4141.22	344,437
4141.23	345,226
4141.24	346,015
4141.25	346,805
4141.26	347,594
4141.27	348,384
4141.28	349,174
4141.29	349,964
4141.30	350,753
4141.31	351,543
4141.32	352,333
4141.33	353,123
4141.34	353,913
4141.35	354,703
4141.36	355,493
4141.37	356,283
4141.38	357,073
4141.39	357,864
4141.40	358,654
4141.41	359,445
4141.42	360,235
4141.43	361,026
4141.44	361,817
4141.45	362,609
4141.46	363,400
4141.47	364,192
4141.48	364,984
4141.49	365,776
4141.50	366,567
4141.51	367,360
4141.52	368,151
4141.53	368,944
4141.54	369,735

UKL Elevation (feet)	Active Storage (acre-feet)
4141.55	370,528
4141.56	371,320
4141.57	372,113
4141.58	372,904
4141.59	373,697
4141.60	374,489
4141.61	375,314
4141.62	376,139
4141.63	376,964
4141.64	377,789
4141.65	378,614
4141.66	379,439
4141.67	380,264
4141.68	381,088
4141.69	381,913
4141.70	382,739
4141.71	383,564
4141.72	384,389
4141.73	385,215
4141.74	386,040
4141.75	386,866
4141.76	387,691
4141.77	388,517
4141.78	389,343
4141.79	390,168
4141.80	390,994
4141.81	391,820
4141.82	392,644
4141.83	393,470
4141.84	394,296
4141.85	395,122
4141.86	395,948
4141.87	396,774
4141.88	397,601
4141.89	398,428
4141.90	399,255
4141.91	400,082

UKL Elevation (feet)	Active Storage (acre-feet)
4141.92	400,910
4141.93	401,737
4141.94	402,564
4141.95	403,392
4141.96	404,218
4141.97	405,045
4141.98	405,873
4141.99	406,700
4142.00	407,528
4142.01	408,355
4142.02	409,183
4142.03	410,011
4142.04	410,839
4142.05	411,666
4142.06	412,494
4142.07	413,322
4142.08	414,150
4142.09	414,978
4142.10	415,805
4142.11	416,633
4142.12	417,461
4142.13	418,289
4142.14	419,117
4142.15	419,945
4142.16	420,774
4142.17	421,602
4142.18	422,430
4142.19	423,259
4142.20	424,087
4142.21	424,915
4142.22	425,744
4142.23	426,572
4142.24	427,400
4142.25	428,229
4142.26	429,057
4142.27	429,886
4142.28	430,715

UKL Elevation (feet)	Active Storage (acre-feet)
4142.29	431,544
4142.30	432,372
4142.31	433,201
4142.32	434,031
4142.33	434,861
4142.34	435,691
4142.35	436,521
4142.36	437,351
4142.37	438,181
4142.38	439,012
4142.39	439,841
4142.40	440,671
4142.41	441,501
4142.42	442,332
4142.43	443,162
4142.44	443,993
4142.45	444,823
4142.46	445,654
4142.47	446,484
4142.48	447,315
4142.49	448,145
4142.50	448,976
4142.51	449,807
4142.52	450,638
4142.53	451,467
4142.54	452,298
4142.55	453,129
4142.56	453,960
4142.57	454,791
4142.58	455,622
4142.59	456,453
4142.60	457,284
4142.61	458,115
4142.62	458,946
4142.63	459,778
4142.64	460,609
4142.65	461,440

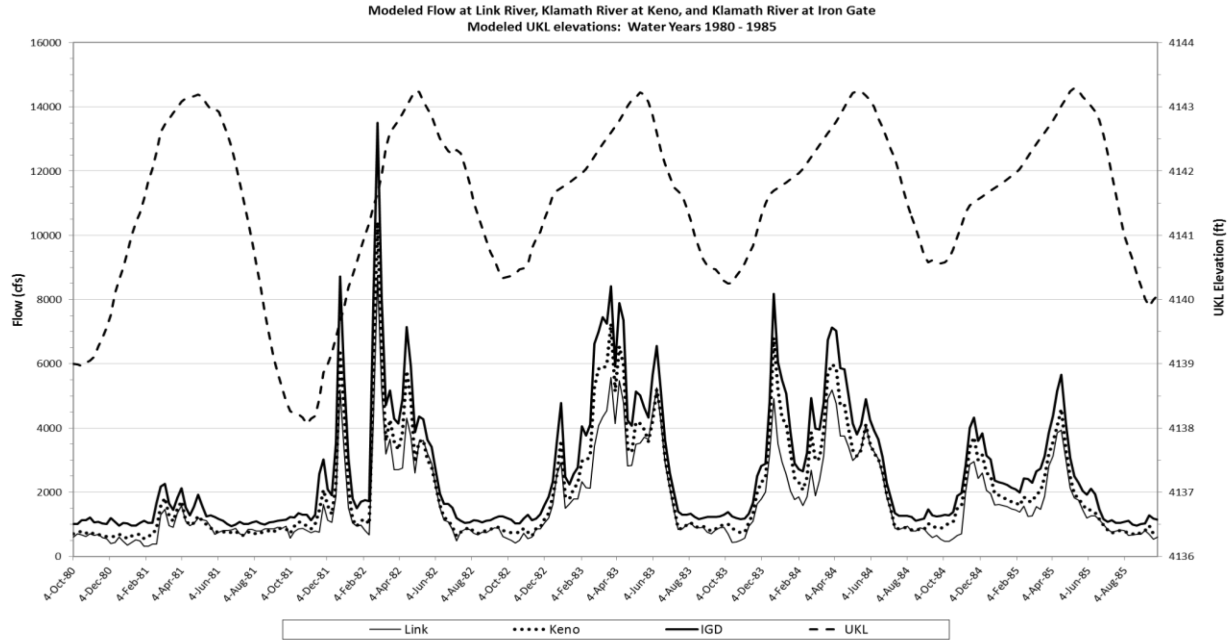
UKL Elevation (feet)	Active Storage (acre-feet)
4142.66	462,271
4142.67	463,102
4142.68	463,933
4142.69	464,764
4142.70	465,596
4142.71	466,427
4142.72	467,259
4142.73	468,090
4142.74	468,922
4142.75	469,754
4142.76	470,586
4142.77	471,419
4142.78	472,252
4142.79	473,085
4142.80	473,918
4142.81	474,749
4142.82	475,582
4142.83	476,415
4142.84	477,248
4142.85	478,081
4142.86	478,914
4142.87	479,747
4142.88	480,581
4142.89	481,414
4142.90	482,247
4142.91	483,080
4142.92	483,914
4142.93	484,747
4142.94	485,580
4142.95	486,413
4142.96	487,246
4142.97	488,080
4142.98	488,913
4142.99	489,747
4143.00	490,580
4143.01	491,414
4143.02	492,248

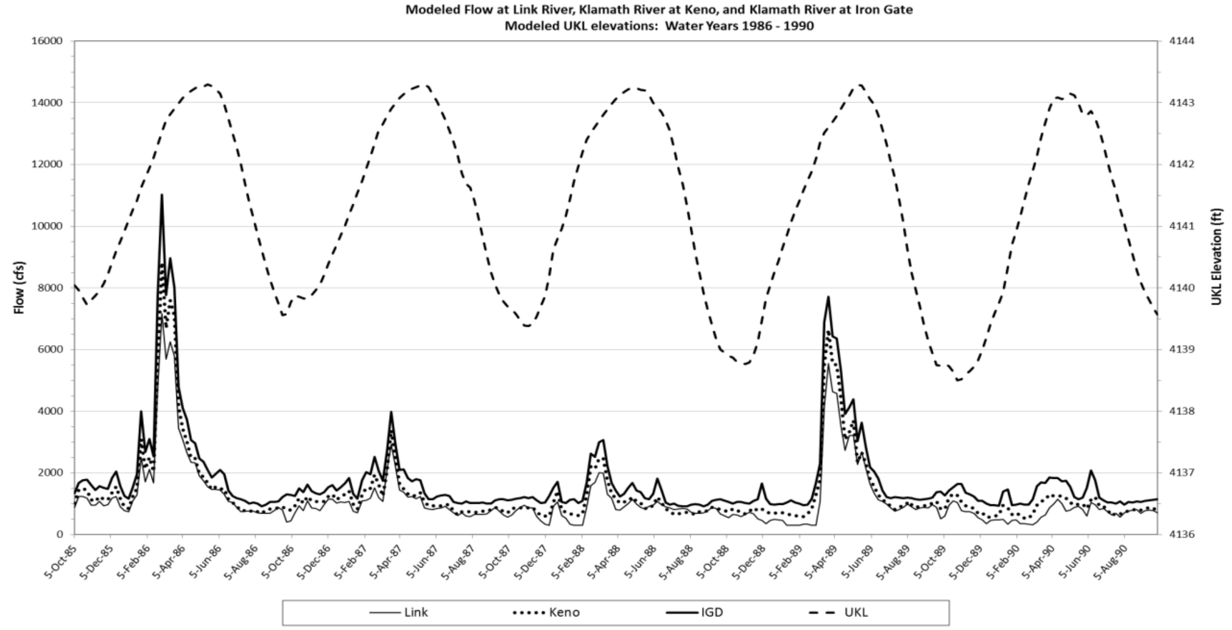
UKL Elevation (feet)	Active Storage (acre-feet)
4143.03	493,081
4143.04	493,915
4143.05	494,749
4143.06	495,583
4143.07	496,417
4143.08	497,250
4143.09	498,083
4143.10	498,917
4143.11	499,751
4143.12	500,585
4143.13	501,420
4143.14	502,254
4143.15	503,088
4143.16	503,922
4143.17	504,756
4143.18	505,591
4143.19	506,425
4143.20	507,260
4143.21	508,096
4143.22	508,931
4143.23	509,766
4143.24	510,601
4143.25	511,437
4143.26	512,272
4143.27	513,108
4143.28	513,944
4143.29	514,779
4143.30	515,615
4143.31	516,181
4143.32	516,995
4143.33	517,808
4143.34	518,621
4143.35	519,434
4143.36	520,247
4143.37	521,061
4143.38	521,874
4143.39	522,687

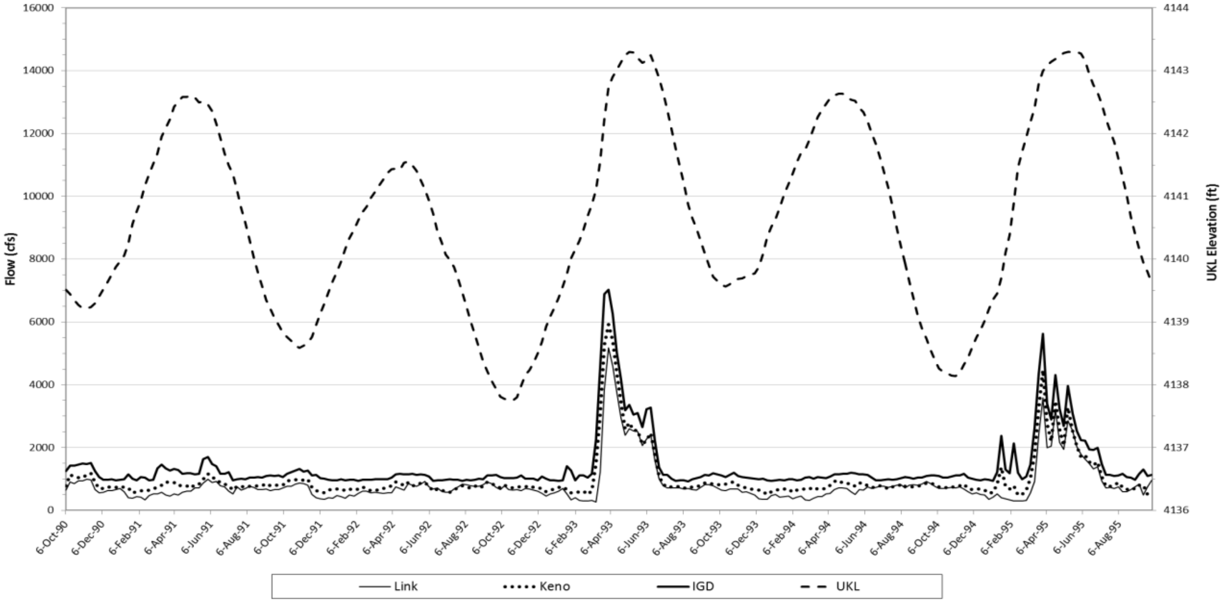
UKL Elevation (feet)	Active Storage (acre-feet)
4143.40	523,500
4143.41	524,313
4143.42	525,127
4143.43	525,940
4143.44	526,753
4143.45	527,566
4143.46	528,379
4143.47	529,192
4143.48	530,006
4143.49	530,819
4143.50	531,632
4143.60	539,498
4143.70	547,460
4143.80	555,420
4143.90	563,383
4144.00	575,634

16.2 Appendix B: Elevation Flow Data

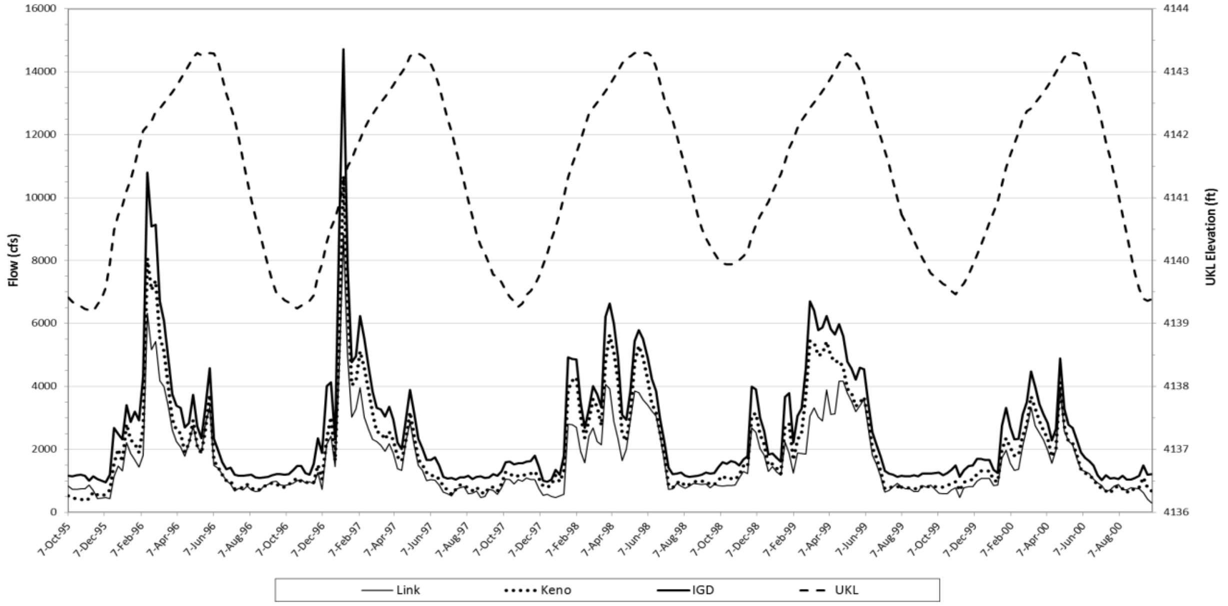
16.2.1 Elevation Flow Data Charts


Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 1980 - 1985

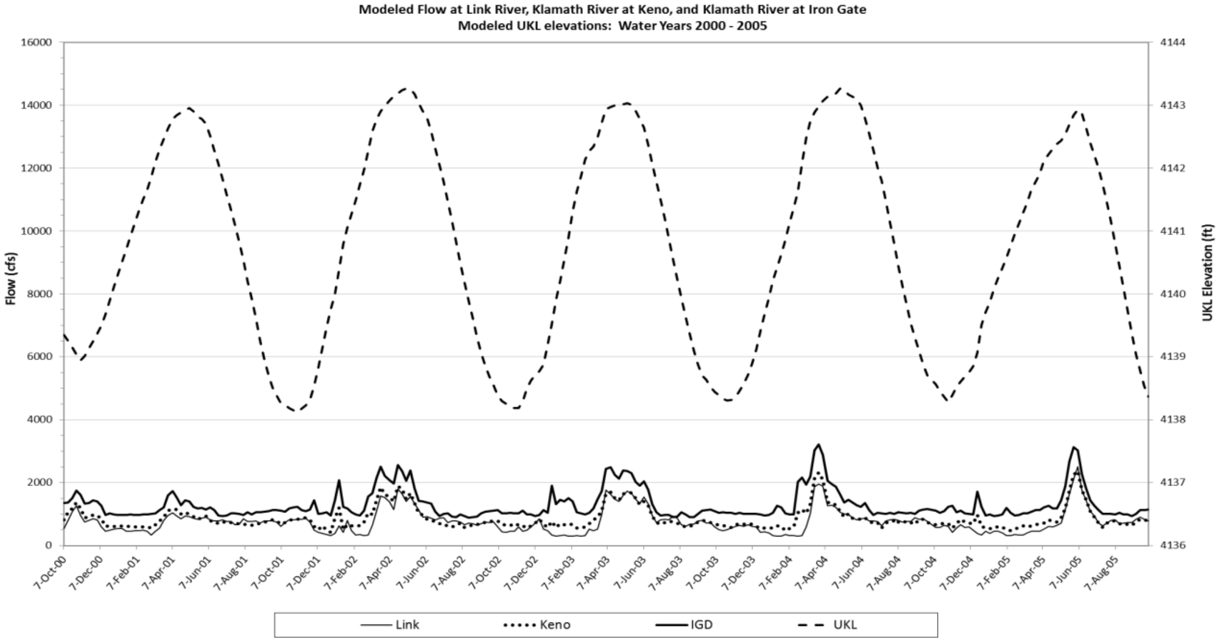

Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 1986 - 1990



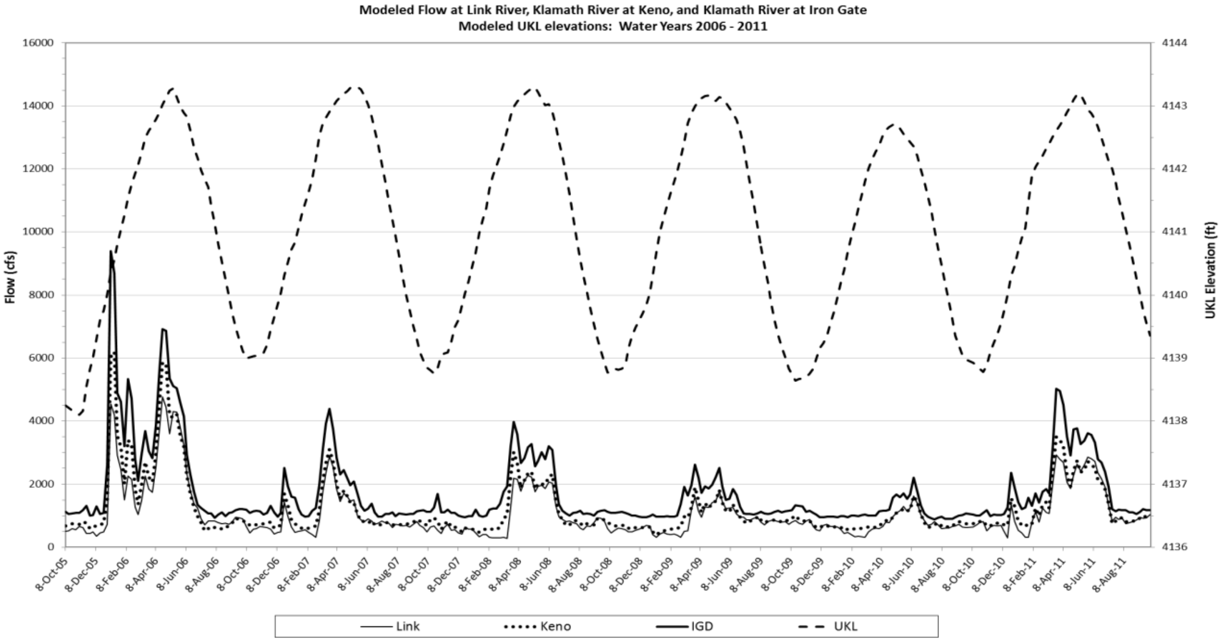
Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 1990 - 1995



Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 1995 - 2000



Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 2000 - 2005



Modeled Flow at Link River, Klamath River at Keno, and Klamath River at Iron Gate
Modeled UKL elevations: Water Years 2006 - 2011

16.2.2 Modeled UKL average weekly elevations (ft) for Period of Record Proposed Action Model Study 2L_MW_7_O dated December 7, 2012

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
7-Oct	4139.00	4138.26	4140.37	4140.25	4140.58	4140.04	4139.77	4139.70	4138.90	4138.76	4139.51
14-Oct	4138.99	4138.22	4140.40	4140.26	4140.64	4139.96	4139.88	4139.65	4138.87	4138.73	4139.44
21-Oct	4138.97	4138.22	4140.47	4140.37	4140.79	4139.84	4139.86	4139.57	4138.80	4138.64	4139.35
28-Oct	4139.01	4138.16	4140.48	4140.45	4140.97	4139.73	4139.83	4139.48	4138.78	4138.50	4139.27
4-Nov	4139.05	4138.06	4140.54	4140.56	4141.15	4139.80	4139.83	4139.39	4138.77	4138.52	4139.22
11-Nov	4139.11	4138.14	4140.80	4140.71	4141.36	4139.88	4139.88	4139.38	4138.80	4138.60	4139.22
18-Nov	4139.27	4138.19	4140.94	4140.83	4141.47	4139.95	4139.97	4139.42	4138.91	4138.65	4139.23
25-Nov	4139.40	4138.45	4141.06	4141.07	4141.52	4140.07	4140.05	4139.54	4139.12	4138.72	4139.30
2-Dec	4139.57	4138.86	4141.26	4141.31	4141.56	4140.22	4140.21	4139.71	4139.47	4138.83	4139.41
9-Dec	4139.76	4138.99	4141.41	4141.49	4141.61	4140.41	4140.38	4139.87	4139.83	4138.99	4139.52
16-Dec	4140.10	4139.16	4141.62	4141.63	4141.65	4140.60	4140.55	4140.19	4140.04	4139.20	4139.64
23-Dec	4140.31	4139.41	4141.69	4141.70	4141.70	4140.75	4140.69	4140.63	4140.25	4139.42	4139.76
30-Dec	4140.49	4139.65	4141.74	4141.74	4141.74	4140.92	4140.85	4140.80	4140.44	4139.59	4139.87
6-Jan	4140.74	4139.89	4141.78	4141.78	4141.78	4141.09	4141.00	4140.96	4140.66	4139.75	4139.97
13-Jan	4141.00	4140.19	4141.82	4141.82	4141.82	4141.27	4141.19	4141.17	4140.85	4139.93	4140.05
20-Jan	4141.19	4140.37	4141.87	4141.87	4141.87	4141.41	4141.36	4141.44	4141.06	4140.34	4140.24
27-Jan	4141.35	4140.58	4141.92	4141.92	4141.92	4141.62	4141.54	4141.74	4141.25	4140.70	4140.56
3-Feb	4141.56	4140.80	4141.97	4141.97	4141.97	4141.79	4141.73	4141.97	4141.41	4140.91	4140.76
10-Feb	4141.83	4141.00	4142.03	4142.03	4142.03	4141.94	4141.93	4142.20	4141.58	4141.16	4140.93
17-Feb	4142.03	4141.19	4142.13	4142.12	4142.13	4142.11	4142.13	4142.40	4141.74	4141.43	4141.17
24-Feb	4142.30	4141.45	4142.23	4142.22	4142.23	4142.32	4142.34	4142.52	4141.89	4141.68	4141.36
3-Mar	4142.60	4141.66	4142.33	4142.31	4142.33	4142.53	4142.56	4142.61	4142.09	4141.90	4141.52
10-Mar	4142.72	4141.94	4142.42	4142.41	4142.42	4142.72	4142.65	4142.71	4142.36	4142.13	4141.69
17-Mar	4142.81	4142.37	4142.51	4142.50	4142.51	4142.81	4142.79	4142.80	4142.51	4142.44	4141.95
24-Mar	4142.90	4142.60	4142.60	4142.59	4142.60	4142.90	4142.90	4142.89	4142.60	4142.67	4142.08

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
31-Mar	4142.99	4142.69	4142.69	4142.68	4142.69	4142.99	4142.99	4142.98	4142.69	4142.90	4142.23
7-Apr	4143.08	4142.79	4142.79	4142.77	4142.79	4143.08	4143.08	4143.06	4142.79	4143.07	4142.43
14-Apr	4143.14	4142.90	4142.90	4142.88	4142.90	4143.14	4143.14	4143.12	4142.90	4143.09	4142.51
21-Apr	4143.15	4143.02	4143.02	4143.00	4143.02	4143.19	4143.19	4143.17	4143.02	4143.06	4142.58
28-Apr	4143.17	4143.13	4143.10	4143.12	4143.13	4143.24	4143.22	4143.22	4143.11	4143.09	4142.58
5-May	4143.19	4143.24	4143.15	4143.22	4143.25	4143.27	4143.25	4143.25	4143.23	4143.14	4142.60
12-May	4143.16	4143.23	4143.23	4143.24	4143.29	4143.27	4143.29	4143.23	4143.29	4143.12	4142.57
19-May	4143.05	4143.09	4143.19	4143.24	4143.25	4143.30	4143.30	4143.21	4143.28	4142.99	4142.50
26-May	4142.96	4142.97	4143.07	4143.18	4143.16	4143.27	4143.25	4143.20	4143.18	4142.81	4142.51
2-Jun	4142.97	4142.86	4142.87	4143.10	4143.09	4143.22	4143.13	4143.13	4143.06	4142.80	4142.46
9-Jun	4142.92	4142.68	4142.60	4143.00	4143.01	4143.15	4143.02	4143.00	4142.98	4142.86	4142.35
16-Jun	4142.75	4142.51	4142.32	4142.82	4142.93	4142.97	4142.88	4142.93	4142.79	4142.75	4142.16
23-Jun	4142.58	4142.41	4142.11	4142.69	4142.80	4142.74	4142.72	4142.85	4142.56	4142.56	4141.92
30-Jun	4142.38	4142.31	4141.92	4142.51	4142.57	4142.51	4142.55	4142.71	4142.33	4142.32	4141.68
7-Jul	4142.12	4142.26	4141.75	4142.34	4142.28	4142.28	4142.36	4142.55	4142.04	4142.04	4141.49
14-Jul	4141.82	4142.33	4141.69	4142.19	4141.95	4142.01	4142.15	4142.27	4141.77	4141.78	4141.36
21-Jul	4141.53	4142.28	4141.62	4141.97	4141.64	4141.69	4141.85	4141.96	4141.43	4141.57	4141.09
28-Jul	4141.22	4142.07	4141.45	4141.71	4141.31	4141.39	4141.69	4141.67	4141.07	4141.29	4140.81
4-Aug	4140.90	4141.81	4141.24	4141.48	4141.01	4141.13	4141.62	4141.33	4140.62	4141.05	4140.58
11-Aug	4140.55	4141.51	4141.00	4141.29	4140.81	4140.87	4141.41	4140.95	4140.24	4140.79	4140.31
18-Aug	4140.21	4141.31	4140.81	4141.11	4140.62	4140.62	4141.13	4140.56	4139.97	4140.54	4140.03
25-Aug	4139.81	4141.12	4140.63	4140.91	4140.40	4140.36	4140.82	4140.24	4139.70	4140.29	4139.79
1-Sep	4139.43	4140.93	4140.53	4140.69	4140.21	4140.14	4140.53	4139.91	4139.39	4140.09	4139.57
8-Sep	4139.10	4140.74	4140.49	4140.58	4140.02	4139.94	4140.26	4139.63	4139.14	4139.93	4139.34
15-Sep	4138.85	4140.61	4140.47	4140.62	4139.90	4139.76	4140.05	4139.40	4138.95	4139.80	4139.21
22-Sep	4138.64	4140.45	4140.39	4140.57	4140.00	4139.56	4139.89	4139.17	4138.75	4139.67	4139.06
29-Sep	4138.41	4140.34	4140.29	4140.56	4140.06	4139.58	4139.77	4139.00	4138.74	4139.56	4138.95

Week of Water Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
7-Oct	4138.83	4137.81	4139.59	4138.26	4139.42	4139.37	4139.65	4140.02	4139.69
14-Oct	4138.76	4137.78	4139.57	4138.21	4139.34	4139.33	4139.53	4139.96	4139.63
21-Oct	4138.70	4137.76	4139.60	4138.18	4139.30	4139.28	4139.42	4139.94	4139.60
28-Oct	4138.62	4137.75	4139.66	4138.15	4139.28	4139.24	4139.36	4139.94	4139.51
4-Nov	4138.59	4137.80	4139.68	4138.14	4139.23	4139.28	4139.26	4139.95	4139.46
11-Nov	4138.62	4137.98	4139.70	4138.19	4139.21	4139.33	4139.31	4140.01	4139.56
18-Nov	4138.67	4138.15	4139.73	4138.32	4139.19	4139.36	4139.45	4140.07	4139.63
25-Nov	4138.76	4138.23	4139.76	4138.43	4139.30	4139.45	4139.52	4140.14	4139.78
2-Dec	4138.95	4138.35	4139.77	4138.59	4139.39	4139.76	4139.61	4140.39	4139.93
9-Dec	4139.13	4138.50	4139.87	4138.75	4139.57	4139.95	4139.75	4140.56	4140.08
16-Dec	4139.30	4138.68	4140.08	4138.88	4139.95	4140.29	4139.93	4140.71	4140.25
23-Dec	4139.48	4138.92	4140.35	4139.02	4140.48	4140.51	4140.11	4140.82	4140.42
30-Dec	4139.65	4139.09	4140.52	4139.21	4140.73	4140.68	4140.33	4140.93	4140.60
6-Jan	4139.80	4139.23	4140.64	4139.36	4140.88	4140.90	4140.53	4141.09	4140.76
13-Jan	4139.96	4139.39	4140.82	4139.45	4141.10	4141.28	4140.75	4141.24	4140.95
20-Jan	4140.16	4139.56	4141.04	4139.71	4141.28	4141.49	4141.02	4141.38	4141.21
27-Jan	4140.33	4139.76	4141.20	4140.10	4141.52	4141.62	4141.32	4141.57	4141.48
3-Feb	4140.47	4140.01	4141.36	4140.39	4141.82	4141.79	4141.53	4141.79	4141.67
10-Feb	4140.62	4140.15	4141.54	4140.89	4142.07	4141.92	4141.71	4141.93	4141.86
17-Feb	4140.75	4140.29	4141.69	4141.46	4142.14	4142.09	4141.91	4142.10	4142.04
24-Feb	4140.84	4140.47	4141.75	4141.71	4142.21	4142.22	4142.13	4142.23	4142.25
3-Mar	4140.98	4140.69	4141.90	4141.94	4142.37	4142.32	4142.33	4142.33	4142.37
10-Mar	4141.07	4140.87	4142.08	4142.18	4142.42	4142.42	4142.43	4142.42	4142.42
17-Mar	4141.17	4141.11	4142.26	4142.41	4142.50	4142.51	4142.51	4142.51	4142.50
24-Mar	4141.27	4141.56	4142.37	4142.80	4142.59	4142.60	4142.60	4142.60	4142.59

Week of Water Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
31-Mar	4141.37	4142.23	4142.47	4142.99	4142.68	4142.69	4142.69	4142.69	4142.68
7-Apr	4141.43	4142.73	4142.57	4143.08	4142.77	4142.79	4142.79	4142.79	4142.77
14-Apr	4141.44	4142.90	4142.60	4143.14	4142.88	4142.90	4142.90	4142.90	4142.88
21-Apr	4141.43	4143.02	4142.63	4143.19	4142.99	4142.99	4143.02	4143.02	4143.00
28-Apr	4141.54	4143.13	4142.63	4143.24	4143.11	4143.09	4143.13	4143.13	4143.11
5-May	4141.56	4143.25	4142.59	4143.28	4143.23	4143.24	4143.22	4143.25	4143.23
12-May	4141.50	4143.30	4142.54	4143.30	4143.29	4143.30	4143.25	4143.29	4143.30
19-May	4141.40	4143.29	4142.52	4143.30	4143.26	4143.29	4143.30	4143.24	4143.30
26-May	4141.26	4143.20	4142.40	4143.30	4143.27	4143.26	4143.30	4143.15	4143.29
2-Jun	4141.12	4143.13	4142.34	4143.27	4143.30	4143.19	4143.30	4143.03	4143.25
9-Jun	4140.93	4143.16	4142.19	4143.16	4143.29	4143.13	4143.30	4142.84	4143.12
16-Jun	4140.72	4143.24	4142.00	4142.95	4143.16	4142.98	4143.25	4142.58	4142.88
23-Jun	4140.45	4143.08	4141.83	4142.77	4142.91	4142.77	4143.07	4142.36	4142.66
30-Jun	4140.27	4142.88	4141.62	4142.65	4142.65	4142.51	4142.81	4142.18	4142.45
7-Jul	4140.07	4142.65	4141.37	4142.47	4142.45	4142.26	4142.57	4141.96	4142.19
14-Jul	4139.99	4142.37	4141.13	4142.23	4142.25	4142.05	4142.39	4141.75	4141.89
21-Jul	4139.88	4142.07	4140.84	4142.04	4141.93	4141.78	4142.22	4141.53	4141.64
28-Jul	4139.69	4141.76	4140.50	4141.86	4141.59	4141.52	4141.99	4141.25	4141.36
4-Aug	4139.47	4141.48	4140.21	4141.59	4141.28	4141.25	4141.72	4140.99	4141.05
11-Aug	4139.24	4141.20	4139.93	4141.30	4140.97	4140.96	4141.49	4140.74	4140.73
18-Aug	4139.01	4140.87	4139.65	4141.02	4140.69	4140.70	4141.26	4140.60	4140.42
25-Aug	4138.80	4140.65	4139.38	4140.67	4140.45	4140.42	4141.00	4140.48	4140.10
1-Sep	4138.58	4140.49	4139.11	4140.40	4140.18	4140.23	4140.72	4140.32	4139.79
8-Sep	4138.37	4140.29	4138.91	4140.16	4139.92	4140.11	4140.51	4140.17	4139.55
15-Sep	4138.22	4140.09	4138.73	4139.95	4139.68	4139.95	4140.36	4140.04	4139.39
22-Sep	4138.07	4139.90	4138.55	4139.80	4139.49	4139.77	4140.23	4139.92	4139.36
29-Sep	4137.93	4139.72	4138.40	4139.62	4139.44	4139.75	4140.12	4139.80	4139.39

Week of Water Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
7-Oct	4139.35	4138.26	4138.39	4138.44	4138.56	4138.25	4139.00	4138.85	4138.77	4138.83	4138.92
14-Oct	4139.25	4138.24	4138.29	4138.39	4138.46	4138.22	4139.01	4138.81	4138.78	4138.74	4138.88
21-Oct	4139.15	4138.18	4138.26	4138.34	4138.36	4138.17	4139.03	4138.75	4138.83	4138.65	4138.83
28-Oct	4139.04	4138.15	4138.21	4138.31	4138.28	4138.13	4139.04	4138.84	4138.82	4138.67	4138.78
4-Nov	4138.94	4138.12	4138.19	4138.32	4138.39	4138.10	4139.05	4139.03	4138.83	4138.68	4138.89
11-Nov	4139.02	4138.18	4138.19	4138.36	4138.53	4138.16	4139.08	4139.07	4138.89	4138.70	4139.10
18-Nov	4139.13	4138.23	4138.29	4138.46	4138.61	4138.55	4139.21	4139.09	4139.15	4138.75	4139.24
25-Nov	4139.25	4138.32	4138.50	4138.58	4138.69	4138.82	4139.45	4139.26	4139.35	4138.83	4139.38
2-Dec	4139.37	4138.54	4138.63	4138.72	4138.76	4139.00	4139.65	4139.49	4139.48	4138.98	4139.55
9-Dec	4139.50	4138.83	4138.71	4138.89	4138.85	4139.30	4139.85	4139.61	4139.59	4139.16	4139.74
16-Dec	4139.68	4139.14	4138.78	4139.12	4139.07	4139.60	4140.02	4139.84	4139.71	4139.23	4140.00
23-Dec	4139.89	4139.47	4138.88	4139.41	4139.50	4139.75	4140.31	4140.02	4139.83	4139.35	4140.30
30-Dec	4140.11	4139.75	4139.19	4139.68	4139.71	4140.01	4140.51	4140.21	4140.03	4139.55	4140.47
6-Jan	4140.32	4140.00	4139.52	4139.93	4139.87	4140.36	4140.72	4140.44	4140.31	4139.74	4140.70
13-Jan	4140.51	4140.38	4139.90	4140.21	4140.08	4140.56	4140.84	4140.67	4140.67	4139.98	4140.90
20-Jan	4140.72	4140.79	4140.20	4140.42	4140.25	4140.80	4141.07	4140.98	4141.00	4140.18	4141.07
27-Jan	4140.92	4141.05	4140.55	4140.62	4140.41	4141.04	4141.26	4141.19	4141.21	4140.40	4141.47
3-Feb	4141.12	4141.27	4140.89	4140.86	4140.58	4141.27	4141.45	4141.39	4141.42	4140.68	4141.89
10-Feb	4141.31	4141.49	4141.31	4141.13	4140.77	4141.54	4141.63	4141.67	4141.62	4140.92	4142.03
17-Feb	4141.49	4141.74	4141.62	4141.37	4140.95	4141.75	4141.84	4141.89	4141.80	4141.13	4142.12
24-Feb	4141.65	4141.97	4141.87	4141.63	4141.12	4141.93	4142.16	4142.04	4141.96	4141.38	4142.21
3-Mar	4141.86	4142.28	4142.13	4142.08	4141.29	4142.06	4142.53	4142.21	4142.17	4141.60	4142.32
10-Mar	4142.10	4142.59	4142.28	4142.48	4141.46	4142.26	4142.72	4142.40	4142.43	4141.80	4142.40
17-Mar	4142.30	4142.77	4142.34	4142.75	4141.66	4142.50	4142.81	4142.61	4142.72	4142.00	4142.51
24-Mar	4142.47	4142.90	4142.49	4142.89	4141.79	4142.60	4142.90	4142.85	4142.88	4142.15	4142.60

Week of Water Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
31-Mar	4142.63	4142.99	4142.72	4142.98	4141.91	4142.69	4142.99	4142.98	4142.99	4142.27	4142.69
7-Apr	4142.78	4143.08	4142.94	4143.07	4142.12	4142.79	4143.08	4143.07	4143.08	4142.38	4142.79
14-Apr	4142.85	4143.14	4142.98	4143.13	4142.22	4142.90	4143.14	4143.13	4143.12	4142.53	4142.90
21-Apr	4142.88	4143.19	4143.00	4143.15	4142.31	4143.02	4143.19	4143.18	4143.15	4142.61	4142.99
28-Apr	4142.92	4143.24	4143.02	4143.18	4142.39	4143.13	4143.24	4143.23	4143.16	4142.66	4143.09
5-May	4142.95	4143.26	4143.01	4143.27	4142.44	4143.25	4143.28	4143.28	4143.11	4142.70	4143.18
12-May	4142.91	4143.26	4143.03	4143.25	4142.54	4143.27	4143.30	4143.30	4143.08	4142.71	4143.18
19-May	4142.82	4143.18	4143.00	4143.17	4142.70	4143.13	4143.30	4143.22	4143.14	4142.64	4143.07
26-May	4142.78	4143.03	4142.91	4143.13	4142.84	4142.99	4143.26	4143.11	4143.12	4142.56	4142.94
2-Jun	4142.70	4142.90	4142.79	4143.10	4142.93	4142.89	4143.16	4143.01	4143.05	4142.48	4142.88
9-Jun	4142.51	4142.80	4142.64	4143.00	4142.87	4142.83	4143.02	4143.03	4142.97	4142.42	4142.78
16-Jun	4142.28	4142.58	4142.37	4142.79	4142.64	4142.61	4142.83	4142.90	4142.88	4142.36	4142.66
23-Jun	4142.07	4142.30	4142.06	4142.55	4142.41	4142.34	4142.62	4142.69	4142.78	4142.21	4142.49
30-Jun	4141.82	4142.05	4141.78	4142.29	4142.20	4142.18	4142.38	4142.44	4142.60	4141.99	4142.31
7-Jul	4141.57	4141.78	4141.49	4142.02	4142.00	4141.98	4142.08	4142.20	4142.35	4141.80	4142.13
14-Jul	4141.34	4141.47	4141.20	4141.80	4141.74	4141.84	4141.80	4141.91	4142.06	4141.57	4142.01
21-Jul	4141.09	4141.16	4140.88	4141.48	4141.45	4141.71	4141.47	4141.60	4141.75	4141.32	4141.78
28-Jul	4140.82	4140.83	4140.55	4141.14	4141.15	4141.41	4141.19	4141.24	4141.45	4141.04	4141.53
4-Aug	4140.54	4140.49	4140.24	4140.81	4140.80	4141.13	4140.95	4140.88	4141.10	4140.74	4141.30
11-Aug	4140.21	4140.19	4139.94	4140.44	4140.44	4140.80	4140.62	4140.56	4140.76	4140.47	4141.04
18-Aug	4139.93	4139.90	4139.64	4140.13	4140.09	4140.53	4140.30	4140.32	4140.47	4140.18	4140.80
25-Aug	4139.62	4139.62	4139.37	4139.83	4139.73	4140.25	4140.00	4140.06	4140.19	4139.91	4140.53
1-Sep	4139.26	4139.32	4139.10	4139.53	4139.37	4139.98	4139.76	4139.78	4139.88	4139.63	4140.26
8-Sep	4138.97	4139.06	4138.88	4139.31	4139.04	4139.72	4139.51	4139.54	4139.59	4139.36	4140.00
15-Sep	4138.72	4138.86	4138.71	4139.09	4138.78	4139.50	4139.31	4139.31	4139.36	4139.20	4139.76
22-Sep	4138.52	4138.69	4138.63	4138.88	4138.54	4139.29	4139.10	4139.11	4139.17	4139.05	4139.55
29-Sep	4138.38	4138.55	4138.53	4138.70	4138.37	4139.12	4138.96	4138.92	4139.01	4138.97	4139.35

16.2.3 Modeled Link River average weekly flow (cfs) for Period of Record Proposed Action Model Study 2L_MW_7_O dated December 7, 2012

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
7-Oct	598	569	497	714	470	891	437	561	556	611	654	710	667	656	695	827	851
14-Oct	705	777	419	439	473	1231	710	644	660	961	906	768	793	626	693	729	888
21-Oct	670	857	499	450	552	1238	931	784	630	1101	857	770	659	681	710	729	920
28-Oct	628	881	731	509	662	1191	774	885	584	1039	934	831	647	687	731	738	1005
4-Nov	710	808	552	578	703	953	1097	957	654	784	944	865	673	685	714	746	1040
11-Nov	656	738	608	935	2022	954	861	865	719	745	988	853	628	578	746	860	930
18-Nov	682	788	857	1088	2877	1080	858	861	679	739	979	809	708	596	689	687	978
25-Nov	584	765	861	1630	2962	942	786	582	511	689	657	517	680	539	591	429	903
2-Dec	554	1613	1045	1787	2423	978	965	448	467	560	558	410	652	499	520	449	1261
9-Dec	410	1128	1193	2013	2605	1179	1143	337	356	484	580	366	617	365	557	475	730
16-Dec	430	1058	1621	3195	2057	1231	1148	300	461	358	623	345	537	355	516	442	2158
23-Dec	612	1891	2562	4923	1965	909	1032	916	495	455	623	410	458	357	499	1141	2416
30-Dec	469	5186	2929	3509	1607	776	1068	1059	484	486	662	384	535	467	358	1464	1447
6-Jan	348	3252	1504	2941	1626	745	1045	629	457	487	694	483	563	506	426	1324	4646
13-Jan	442	1524	1632	2545	1583	1097	1085	525	311	502	592	447	614	421	532	2209	8872
20-Jan	515	1044	1783	2035	1556	1295	765	339	300	337	399	382	691	439	413	1871	4985
27-Jan	484	950	1781	1779	1489	2497	703	301	300	459	381	489	523	452	368	1663	3032
3-Feb	318	985	2324	1858	1453	1721	1099	308	302	488	437	465	342	376	338	1428	3284
10-Feb	322	802	2137	1581	1387	2119	1121	300	342	355	416	537	413	417	302	1817	3963
17-Feb	378	665	2133	1858	1573	1674	1186	886	347	351	339	617	319	464	301	6321	3018
24-Feb	391	4241	3428	2677	1244	4777	1528	1584	301	342	478	615	300	339	302	5167	2649
3-Mar	1305	8754	4066	1888	1264	7169	1210	1700	311	320	523	557	306	322	317	5433	2326
10-Mar	1473	5192	4334	2373	1555	5685	1086	2003	1078	419	535	574	319	391	569	4185	2251
17-Mar	967	3185	4544	3132	1471	6259	2122	1998	4127	565	577	563	260	437	921	3987	2119
24-Mar	904	3648	5582	4914	1865	5803	2926	1305	5543	638	486	545	1224	447	2424	3393	1933

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
31-Mar	1357	2695	4136	5191	2825	3457	2228	1188	4632	874	456	554	3842	530	3592	2610	2178
7-Apr	1588	2705	5475	4766	3131	3093	1445	815	4578	987	520	567	5169	538	1999	2253	1875
14-Apr	1094	2754	4782	3751	3849	2670	1385	797	3526	1143	492	752	4604	659	2053	2073	1379
21-Apr	961	4303	2812	3754	3931	2342	1225	897	2734	1005	586	707	3758	725	3224	1779	1331
28-Apr	1030	3750	2835	3413	2982	2324	1236	1007	3203	766	621	642	2945	715	2166	2193	2225
5-May	1202	2608	3490	2993	2124	1903	1170	1150	3218	806	610	857	2390	705	1952	2724	2873
12-May	1143	3567	3525	3121	1823	1750	1237	986	2279	886	720	800	2596	593	2854	2085	2127
19-May	1111	3612	3722	3365	1747	1548	862	893	2686	925	709	761	2524	517	2529	1886	1485
26-May	929	3201	3644	4098	1446	1460	833	827	2160	809	880	839	2522	659	2035	2828	1324
2-Jun	694	2899	4466	3459	1190	1462	823	914	1650	601	987	918	2066	642	1780	3333	1007
9-Jun	759	2154	5259	3264	1271	1448	842	949	1339	1039	896	754	2276	743	1638	1485	1044
16-Jun	809	1512	4189	3035	1265	1306	863	1083	1137	968	923	686	2405	691	1488	1404	1017
23-Jun	805	1136	2911	2557	1151	1077	922	965	1077	821	778	721	1605	728	1327	1218	867
30-Jun	826	1079	2104	1862	993	1036	820	910	997	850	751	611	1010	771	1390	999	640
7-Jul	881	834	1411	1410	843	882	705	866	861	752	621	584	788	775	941	909	596
14-Jul	706	482	849	870	752	743	617	813	758	643	522	571	716	729	724	680	529
21-Jul	664	775	858	844	798	758	709	841	815	699	745	678	719	770	729	761	725
28-Jul	839	844	973	893	826	765	603	843	880	562	646	754	723	804	705	717	773
4-Aug	845	837	1047	936	812	756	591	841	985	708	703	833	717	823	757	824	807
11-Aug	785	730	911	784	651	707	659	730	898	755	763	819	685	724	589	703	590
18-Aug	799	675	887	798	673	699	656	688	820	801	737	781	695	800	596	661	606
25-Aug	858	752	902	885	685	695	650	692	867	817	657	777	664	826	657	684	670
1-Sep	855	735	758	853	684	694	666	707	880	699	666	767	651	799	755	825	477
8-Sep	855	819	707	714	815	786	771	777	869	778	679	827	732	841	831	880	503
15-Sep	910	897	822	589	696	889	878	886	978	793	626	913	820	926	494	973	727
22-Sep	884	880	889	659	529	804	767	851	881	780	671	854	821	861	755	985	701
29-Sep	949	624	909	536	600	406	634	668	509	706	664	742	788	766	963	864	566

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
7-Oct	772	855	613	550	620	590	601	587	511	662	483	598	736	646
14-Oct	1054	828	595	803	740	446	514	587	521	456	642	445	795	718
21-Oct	1031	843	595	1074	826	427	478	647	591	578	676	535	846	772
28-Oct	897	858	710	1271	825	461	508	613	562	588	532	609	762	813
4-Nov	1033	866	779	961	832	458	559	420	659	651	433	588	723	529
11-Nov	981	1090	471	746	833	593	620	560	630	637	626	552	832	647
18-Nov	1086	1290	785	809	868	462	647	668	433	633	728	485	878	692
25-Nov	1045	1224	806	851	745	489	618	578	442	576	544	489	661	675
2-Dec	1045	2678	817	814	497	602	659	598	493	413	555	541	551	685
9-Dec	751	2545	984	603	431	716	606	492	355	478	451	566	522	507
16-Dec	540	2024	1067	456	391	848	597	390	458	492	419	622	698	306
23-Dec	574	1810	1069	494	351	535	430	331	490	1430	649	698	725	1356
30-Dec	507	1298	1078	531	327	477	441	463	736	985	578	668	664	818
6-Jan	463	1447	846	549	383	341	409	381	4549	643	580	409	651	547
13-Jan	513	1277	866	547	626	301	312	450	4203	474	454	315	640	460
20-Jan	565	1173	1728	466	430	315	301	463	2917	510	339	413	571	320
27-Jan	2804	2227	1974	463	802	339	306	398	2472	516	406	473	444	307
3-Feb	2778	1872	1559	474	469	306	353	313	1503	551	400	414	467	788
10-Feb	2694	1245	1337	473	331	304	313	318	2265	469	319	400	394	1116
17-Feb	1932	1889	1361	486	355	326	324	362	2147	393	301	419	335	795
24-Feb	1578	1865	2110	450	328	304	307	338	1278	307	303	378	346	1240
3-Mar	2419	1859	2672	333	339	321	314	337	1046	852	302	310	340	1101
10-Mar	2688	3059	3335	454	643	524	595	398	1478	1782	312	502	307	1073
17-Mar	2252	3322	2754	568	1104	474	1031	461	2254	2353	289	527	493	1992
24-Mar	2144	3027	2528	806	1587	519	1877	457	1842	2903	1282	1197	571	2930

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
31-Mar	4062	2909	2297	956	1528	1000	1961	456	1743	2559	2186	1610	602	2792
7-Apr	3925	3880	1968	1042	1383	1775	1895	526	2556	1842	2151	1134	595	2686
14-Apr	2895	3107	1565	933	1140	1624	1273	616	3751	1459	1770	952	663	2074
21-Apr	2335	3135	1992	860	1805	1474	1291	594	4765	1712	2127	1270	799	1857
28-Apr	1644	4165	3919	935	1652	1402	1212	654	4435	1605	2270	1261	780	2269
5-May	2014	4171	2583	918	1399	1598	1060	717	3591	1460	2230	1419	968	2635
12-May	2950	3781	2267	865	1567	1726	1012	1146	4305	1495	1762	1472	1087	2412
19-May	3852	3520	2138	838	1335	1665	997	1656	4291	996	1939	1767	1163	2595
26-May	3797	3201	1718	877	1124	1481	895	2106	3787	860	1971	1449	1290	2865
2-Jun	3570	3384	1350	910	904	1336	824	2504	3240	816	1866	1233	1143	2809
9-Jun	3397	3598	1301	816	917	1547	852	1744	2341	892	2077	1245	1248	2716
16-Jun	3207	2679	1221	782	869	1342	876	1445	1792	828	2042	1255	1628	2363
23-Jun	3061	1811	1059	790	815	956	792	1088	1383	722	1306	1059	1405	2172
30-Jun	2400	1526	937	827	872	727	785	938	1236	757	970	949	1041	1920
7-Jul	1604	1132	857	766	886	825	767	725	892	839	878	946	845	1308
14-Jul	727	647	665	767	727	831	625	623	718	774	820	873	690	824
21-Jul	748	694	707	671	782	825	781	715	838	766	831	861	725	946
28-Jul	915	810	827	688	791	942	818	797	839	629	785	922	816	891
4-Aug	829	923	889	847	749	875	845	822	837	723	745	949	716	909
11-Aug	758	820	717	776	665	656	798	707	776	705	604	799	584	740
18-Aug	833	753	709	771	714	621	744	725	745	680	548	703	608	773
25-Aug	919	746	782	781	708	676	771	731	754	696	669	817	603	822
1-Sep	904	659	766	708	645	679	764	732	735	641	663	840	660	869
8-Sep	885	662	754	779	693	784	892	831	795	736	779	841	680	945
15-Sep	908	848	633	789	745	804	844	905	946	808	926	810	722	918
22-Sep	775	799	419	792	731	722	852	831	930	690	912	798	644	937
29-Sep	887	868	290	743	759	727	769	782	898	627	809	821	631	1046

16.2.4 Modeled Klamath River at Keno average weekly flow (cfs) for Period of Record Proposed Action Model Study 2L_MW_7_O dated December 7, 2012

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
7-Oct	709	726	732	1014	937	1026	802	710	749	835	784	812	716	796	749	519	797
14-Oct	747	947	754	870	1043	1447	940	843	832	1207	1139	937	798	831	748	459	882
21-Oct	798	1083	741	804	1078	1497	1189	868	803	1325	1076	954	755	883	718	440	995
28-Oct	725	1039	877	739	1507	1426	1028	863	704	1273	1048	975	725	914	741	418	1086
4-Nov	778	948	765	752	1573	1134	1243	879	679	1066	1051	990	746	798	766	361	978
11-Nov	688	863	643	1070	2408	1085	1101	868	769	938	1127	960	746	748	792	439	938
18-Nov	696	1007	877	1338	3396	1243	1081	882	862	907	1177	993	748	711	831	646	962
25-Nov	638	1429	902	1990	3714	1156	1056	744	788	857	894	738	781	686	698	558	949
2-Dec	617	2084	1167	2313	3004	1128	1080	626	833	696	703	630	737	661	672	516	1498
9-Dec	627	1579	1352	2448	3161	1368	1235	602	745	701	695	601	719	653	674	578	1054
16-Dec	628	1310	1870	3962	2606	1553	1315	603	692	569	751	570	704	595	676	713	2348
23-Dec	688	2251	2555	6807	2515	1172	1129	1043	692	570	733	655	588	512	655	1566	3028
30-Dec	631	6344	3612	5204	1935	910	1237	1413	720	606	742	674	655	594	541	2003	1642
6-Jan	549	4478	1881	4309	1903	844	1315	802	715	648	761	688	676	636	581	1610	5308
13-Jan	632	2139	1793	4123	1826	1232	1407	728	672	961	727	680	729	681	832	2796	10672
20-Jan	688	1162	2111	3254	1781	1496	988	666	646	875	716	638	745	676	1380	2303	6766
27-Jan	684	936	2275	2450	1711	3089	840	665	616	650	565	674	670	686	775	2184	4040
3-Feb	551	1119	2980	2314	1679	2137	1296	627	581	716	603	655	561	579	678	1909	4159
10-Feb	647	1167	2972	2073	1591	2497	1523	679	578	615	627	682	554	641	784	2704	5122
17-Feb	668	1011	3135	2473	1858	2043	1495	1266	666	526	609	757	600	656	487	8075	4591
24-Feb	896	5558	5277	3864	1714	5555	1949	2209	850	536	639	679	617	691	515	7060	3882
3-Mar	1561	10411	5846	2991	1702	8827	1626	2126	1293	669	678	631	513	712	651	7360	3166
10-Mar	1820	6193	5837	3048	1934	6687	1257	2465	1791	952	748	646	635	643	1030	5566	2558
17-Mar	1273	3605	5981	3913	2020	7587	2089	2473	5502	1085	811	655	1501	694	1776	5109	2529
24-Mar	1104	4258	7257	5696	2474	7096	3383	1753	6636	1134	903	705	3045	677	3260	4024	2314

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
31-Mar	1492	3574	5133	5980	3197	4164	2505	1343	5548	1305	890	729	5257	706	4473	2961	2560
7-Apr	1728	3330	6534	5884	3570	3446	1654	1165	5496	1259	884	791	5924	807	2751	2608	2274
14-Apr	1133	3875	5969	4696	4060	3024	1478	1022	4431	1249	788	910	5421	923	2212	2513	1768
21-Apr	973	5780	3355	4705	4595	2481	1319	1070	3089	1257	803	865	4364	957	3482	1927	1635
28-Apr	1046	4896	3242	3962	3293	2462	1264	1093	3320	1190	787	784	3440	877	2585	2181	2283
5-May	1267	2940	4181	3304	2485	1983	1267	1225	3695	1044	725	896	2587	864	2073	2916	3186
12-May	1106	3573	4138	3131	1936	1875	1369	1071	2352	962	824	793	2791	859	3279	2111	2424
19-May	1001	3638	3958	3304	1807	1678	1065	1021	2671	994	838	796	2550	773	2524	1863	1673
26-May	894	3003	3581	4099	1614	1473	937	846	2311	993	987	871	2545	868	2040	2660	1503
2-Jun	768	2778	4223	3536	1450	1555	940	859	1798	851	1165	883	2092	874	1707	3729	1258
9-Jun	765	2193	5209	3215	1454	1486	912	949	1546	1136	1040	773	2235	784	1746	1648	1159
16-Jun	772	1603	4417	3037	1364	1490	942	1225	1297	1212	1014	621	2469	729	1543	1428	1170
23-Jun	729	1217	3062	2648	1169	1157	966	1044	1125	937	870	674	1793	740	1447	1192	1058
30-Jun	756	1124	2202	1935	981	1045	978	841	1036	929	846	651	1098	786	1539	1003	829
7-Jul	786	933	1549	1471	821	916	770	755	912	790	778	589	841	753	1078	1012	704
14-Jul	678	639	868	896	724	772	636	650	817	629	642	572	742	687	766	745	570
21-Jul	648	757	866	861	784	781	736	668	884	697	762	663	760	748	761	773	724
28-Jul	756	847	970	891	815	739	753	713	951	682	766	719	754	770	805	779	866
4-Aug	766	906	1060	917	797	796	739	732	1030	711	739	786	768	815	881	878	870
11-Aug	684	766	930	832	718	737	736	691	975	787	769	736	715	771	737	776	765
18-Aug	740	718	916	800	704	695	718	656	891	806	776	723	708	745	667	694	697
25-Aug	764	732	937	865	669	797	755	753	919	839	794	781	746	751	720	726	791
1-Sep	806	824	863	842	763	831	754	737	945	798	790	724	756	777	680	830	642
8-Sep	751	844	789	1025	810	852	810	778	955	839	856	767	800	804	796	845	585
15-Sep	896	914	865	932	962	863	880	878	1024	879	777	905	871	880	802	931	800
22-Sep	859	916	959	909	708	898	848	859	1071	856	808	852	843	879	517	907	803
29-Sep	857	804	976	884	692	807	750	808	825	790	803	789	852	824	541	794	677

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
7-Oct	896	1014	815	820	686	780	697	660	671	813	693	784	844	743
14-Oct	1278	1155	790	1063	734	684	651	685	730	695	881	720	917	817
21-Oct	1226	1055	846	1185	802	654	641	710	748	726	935	671	996	812
28-Oct	1124	1070	920	1370	831	670	596	706	735	718	817	684	882	827
4-Nov	1153	1036	962	1174	838	613	581	562	722	720	569	693	859	670
11-Nov	1143	1193	696	895	875	688	669	693	807	745	710	687	802	672
18-Nov	1235	1470	946	911	897	631	701	836	769	780	823	615	838	762
25-Nov	1231	1442	1029	981	814	562	686	750	593	801	638	571	734	768
2-Dec	1296	3071	1041	956	617	630	696	724	630	615	639	629	624	775
9-Dec	1082	3139	1209	858	518	716	690	704	697	644	567	625	618	706
16-Dec	830	2481	1322	614	628	840	617	973	705	704	490	627	702	688
23-Dec	803	2167	1300	624	488	690	549	609	766	1686	608	630	694	1558
30-Dec	865	1497	1308	605	424	584	565	557	1526	1333	588	635	629	1287
6-Jan	1184	1543	1030	600	872	772	559	548	6039	859	576	493	645	811
13-Jan	973	1398	963	629	1201	580	554	542	6192	741	551	389	658	704
20-Jan	1314	1232	1988	606	509	703	629	607	3532	666	464	481	638	665
27-Jan	3888	2759	2354	622	673	660	609	574	3187	605	543	527	537	765
3-Feb	4184	2804	2056	603	622	702	475	532	2018	578	587	546	570	738
10-Feb	4279	1661	1802	593	656	663	538	482	3394	605	571	568	616	1237
17-Feb	3055	2302	1816	589	625	568	602	535	3253	637	573	586	578	1005
24-Feb	2363	2533	2436	595	750	568	1044	577	1847	676	555	594	573	1342
3-Mar	2914	3721	2783	556	1048	601	1148	633	1360	1184	647	654	604	1438
10-Mar	3601	5441	3684	667	994	707	1028	594	2000	2132	881	961	626	1242
17-Mar	3361	5396	3307	787	1435	827	1319	639	2708	2675	1051	933	646	2450
24-Mar	2770	4981	2913	912	1852	913	2136	669	2228	3097	2255	1266	660	3498

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
31-Mar	4803	5052	2586	1106	1625	1106	2327	705	2070	2725	3021	1890	633	3402
7-Apr	5641	5433	2345	1168	1537	1649	2088	720	2965	1996	2675	1478	679	3194
14-Apr	5074	4984	1767	1145	1410	1700	1368	826	4632	1543	1883	1099	782	2300
21-Apr	4183	4765	2035	1011	1887	1510	1365	767	5844	1787	2129	1393	851	1923
28-Apr	2493	4825	4137	1059	1807	1435	1288	756	5823	1624	2347	1235	832	2432
5-May	2267	4598	2728	997	1476	1650	1090	884	4162	1417	2399	1376	958	2738
12-May	3149	3926	2256	921	1664	1664	909	1176	4120	1420	1848	1473	1086	2387
19-May	4769	3781	2199	835	1349	1679	1004	1759	4214	1050	2023	1810	1118	2442
26-May	5286	3379	1828	881	1026	1512	878	2250	3539	832	2004	1420	1233	2728
2-Jun	4919	3491	1371	935	978	1305	860	2365	3179	820	2002	1152	1161	2613
9-Jun	4214	3665	1254	800	844	1413	833	1769	2278	771	2223	1119	1183	2519
16-Jun	3439	2942	1169	723	821	1284	888	1464	1686	854	2307	1342	1616	2141
23-Jun	3185	2064	1062	721	751	933	770	1094	1267	713	1470	1170	1426	2056
30-Jun	2482	1738	856	766	694	735	710	900	988	689	1056	952	1056	1840
7-Jul	1794	1312	765	725	697	689	734	721	779	720	863	826	788	1375
14-Jul	864	750	672	728	617	729	555	583	517	779	687	761	631	742
21-Jul	783	778	612	708	602	789	714	721	588	786	706	828	656	829
28-Jul	931	822	778	698	648	756	787	793	662	709	834	882	718	920
4-Aug	982	822	835	689	718	713	780	783	626	709	854	953	775	942
11-Aug	840	806	750	668	574	647	743	695	572	706	758	873	678	822
18-Aug	883	767	626	655	615	600	709	672	592	721	682	786	626	805
25-Aug	960	775	745	692	657	613	777	683	597	734	750	832	657	828
1-Sep	997	760	713	706	657	672	729	653	708	757	731	846	663	838
8-Sep	995	732	798	741	741	744	677	753	763	794	717	869	770	939
15-Sep	983	834	1102	805	734	797	845	838	920	878	911	843	811	995
22-Sep	890	808	787	826	773	785	837	814	888	834	904	800	777	951
29-Sep	879	819	670	792	789	737	734	784	833	761	861	848	737	939

16.2.5 Modeled Klamath River below Iron Gate Dam average weekly flow (cfs) for Period of RecordProposed Action Model Study 2L_MW_7_O dated December 7, 2012

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
7-Oct	1016	1229	1142	1384	1292	1350	1283	1108	1056	1267	1245	1070	1059	1117	1095	1158	1202
14-Oct	1005	1206	1029	1245	1279	1686	1264	1127	1013	1432	1433	1166	1027	1057	1040	1138	1206
21-Oct	1121	1346	1033	1204	1376	1767	1503	1170	1069	1533	1426	1227	1025	1130	1051	1180	1333
28-Oct	1126	1305	1183	1165	1887	1778	1372	1186	1061	1649	1467	1269	1034	1193	1081	1194	1479
4-Nov	1209	1302	1299	1174	1982	1602	1618	1223	1033	1640	1487	1324	1048	1091	1110	1167	1468
11-Nov	1070	1134	1129	1331	2840	1455	1419	1184	1005	1358	1478	1238	1107	1070	1115	1009	1253
18-Nov	1081	1293	1182	1665	4011	1580	1343	1226	1089	1307	1516	1274	1014	1042	1164	1138	1200
25-Nov	1024	2574	1316	2500	4322	1518	1316	1113	1150	1243	1258	1115	1014	1026	1042	1053	1539
2-Dec	1015	3027	1601	2827	3603	1479	1372	1029	1666	1094	1055	1136	1013	1011	1018	1011	2351
9-Dec	1198	2089	1862	2888	3831	1828	1535	1045	1159	1101	976	1028	962	989	972	955	1892
16-Dec	1085	1899	2333	4834	3146	2041	1615	1262	983	1014	982	1004	1073	1013	964	1195	4005
23-Dec	960	3526	3590	8182	3019	1568	1425	1521	969	952	991	969	1017	965	991	2673	4127
30-Dec	1037	8727	4779	6047	2363	1262	1538	1710	988	952	961	959	957	947	971	2496	2319
6-Jan	1026	5539	2475	5492	2306	1169	1655	1066	990	945	977	952	955	955	949	2317	8968
13-Jan	956	3057	2237	5064	2272	1539	1835	1021	1043	1401	991	987	945	970	1214	3408	14715
20-Jan	953	1802	2559	3887	2225	1964	1331	1139	1116	1461	1156	953	962	954	2379	2864	7804
27-Jan	1050	1502	2770	2908	2139	4010	1159	1153	1037	960	1014	970	1405	985	1302	3190	4769
3-Feb	1118	1709	4051	2714	2096	2673	1758	1031	1009	978	959	973	1271	1000	1181	2914	4960
10-Feb	1052	1761	3767	2656	1986	3102	2022	1105	947	1007	1054	934	965	961	2138	4317	6240
17-Feb	1052	1720	4100	3233	2424	2540	1967	1673	974	974	1050	972	1117	973	1209	10791	5527
24-Feb	1671	7915	6621	4940	2411	7759	2528	2624	1163	969	962	971	1112	1037	991	9096	4647
3-Mar	2181	13509	6995	3992	2304	11032	2063	2522	1671	1153	974	977	1038	1062	1080	9140	3836
10-Mar	2265	8017	7460	3955	2648	7776	1749	3000	2319	1573	1341	989	1166	1006	1463	6713	3322
17-Mar	1649	4709	7249	4783	2735	8963	2721	3070	6882	1700	1465	993	2251	1061	2631	6078	3273
24-Mar	1445	5171	8423	6736	3130	8017	3986	2231	7715	1678	1335	998	4575	1040	4370	4923	3043

Week of Water Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
31-Mar	1815	4290	5912	7136	3853	4801	2947	1682	6429	1860	1274	994	6896	1020	5619	3750	3351
7-Apr	2121	4131	7891	7021	4380	4114	2103	1433	6357	1835	1322	1048	7029	1080	3399	3385	2948
14-Apr	1530	4898	7345	5865	5157	3742	2126	1239	5318	1845	1291	1144	6259	1142	2903	3319	2222
21-Apr	1281	7145	4242	5821	5665	3068	1844	1319	3912	1725	1166	1175	5018	1153	4313	2692	2004
28-Apr	1548	5925	4076	5006	4108	2971	1738	1524	4118	1756	1184	1151	4168	1166	3239	2829	2932
5-May	1930	3876	5142	4137	3071	2464	1795	1681	4390	1553	1179	1150	3186	1160	2682	3740	3884
12-May	1566	4356	5014	3804	2499	2366	1762	1428	3037	1214	1143	1163	3359	1193	3965	2725	3151
19-May	1254	4272	4633	4097	2303	2093	1344	1386	3640	1147	1170	1138	3048	1188	3079	2348	2343
26-May	1273	3626	4324	4900	2039	1851	1145	1190	2842	1195	1625	1150	3103	1145	2537	3367	2020
2-Jun	1232	3408	5648	4249	1922	1983	1153	1155	2197	1517	1709	1140	2646	1145	2240	4578	1657
9-Jun	1167	2662	6562	3925	2116	2102	1232	1324	2042	2078	1479	1078	3222	1129	2226	2335	1667
16-Jun	1118	1963	5129	3653	1935	1956	1264	1821	1811	1759	1402	938	3275	1037	1946	1969	1749
23-Jun	1016	1629	3608	3114	1471	1435	1288	1446	1431	1211	1174	956	2216	955	1929	1588	1494
30-Jun	945	1633	2606	2298	1156	1261	1259	1050	1229	1116	1169	956	1374	952	1987	1365	1123
7-Jul	1002	1510	1998	1824	1077	1182	1056	980	1180	1049	1216	976	1124	980	1480	1411	1082
14-Jul	1072	1202	1403	1353	1122	1151	1028	1012	1220	1039	960	986	1124	997	1136	1196	1092
21-Jul	1014	1118	1305	1257	1049	1100	1016	937	1211	1006	993	972	1007	982	1140	1168	1045
28-Jul	1017	1044	1291	1271	1051	1005	1079	924	1192	1071	1006	979	948	992	1101	1161	1110
4-Aug	1064	1062	1324	1260	1085	1041	1021	921	1208	979	991	950	964	1028	1116	1169	1114
11-Aug	1089	1128	1225	1230	1110	1010	1021	970	1178	1061	1043	971	963	1063	1161	1203	1152
18-Aug	1031	1105	1169	1115	986	917	1026	995	1149	1046	1038	958	925	1040	1062	1107	1054
25-Aug	993	1062	1196	1154	962	980	1039	968	1125	1082	1055	984	999	1017	1050	1094	1118
1-Sep	1059	1119	1224	1173	1017	1061	1009	927	1143	1059	1052	1010	1020	1041	968	1106	1137
8-Sep	1083	1129	1239	1463	1024	1068	1011	966	1168	1091	1092	999	1062	1047	1172	1128	1089
15-Sep	1114	1200	1226	1282	1290	1085	1118	1088	1210	1111	1116	1110	1133	1098	1313	1179	1112
22-Sep	1124	1241	1250	1247	1177	1213	1158	1135	1383	1128	1095	1116	1117	1121	1099	1213	1215
29-Sep	1143	1251	1292	1265	1151	1304	1158	1158	1394	1144	1111	1125	1185	1117	1128	1210	1152

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
7-Oct	1293	1438	1256	1346	1118	1136	1103	1110	1115	1199	1120	1123	1161	1037
14-Oct	1592	1587	1183	1372	1085	1031	1043	1040	1062	1089	1131	1087	1176	1010
21-Oct	1605	1546	1245	1516	1174	1020	1060	1096	1078	1137	1254	1085	1326	1009
28-Oct	1518	1624	1350	1758	1216	1046	1042	1236	1086	1150	1691	1110	1315	1097
4-Nov	1565	1599	1496	1618	1237	1035	1042	1264	1085	1146	1107	1120	1297	1182
11-Nov	1554	1488	1123	1341	1134	1022	1002	1068	1173	1038	1100	1086	1119	994
18-Nov	1610	1685	1330	1354	1103	1120	1038	1115	1318	1086	1193	1058	1153	1042
25-Nov	1624	1782	1474	1433	1150	991	1015	1031	1010	1320	1090	1001	1087	1016
2-Dec	1797	3984	1497	1406	1435	994	1011	1010	1027	1108	1081	1001	1032	1012
9-Dec	1431	3907	1702	1266	1013	938	1005	986	1303	977	1000	967	956	1049
16-Dec	1001	3016	1703	984	1029	976	1002	1712	1057	1096	960	955	960	1270
23-Dec	973	2572	1654	1031	1055	1136	1000	1241	1090	2513	955	958	976	2364
30-Dec	1044	1825	1656	996	963	1037	957	951	2610	1924	983	990	969	1885
6-Jan	1357	1865	1347	968	1442	1909	979	994	9401	1603	979	1044	963	1430
13-Jan	1199	1723	1252	984	2078	1320	1043	940	8680	1569	1196	969	958	1213
20-Jan	1791	1604	2750	980	1241	1453	1268	965	4890	1213	1009	964	993	1268
27-Jan	4934	3670	3314	988	1177	1415	1222	994	4619	1029	967	971	978	1576
3-Feb	4875	3788	2710	977	1061	1504	1019	1201	3200	967	998	983	954	1307
10-Feb	4863	2222	2322	973	998	1405	996	1045	5340	985	1184	968	1002	1702
17-Feb	3511	3054	2327	988	967	1065	984	953	4711	1152	1227	970	1003	1413
24-Feb	2685	3293	3107	999	1106	1021	2026	974	2787	1250	1218	1001	989	1765
3-Mar	3292	4561	3503	1016	1568	997	2170	1025	2099	1981	1384	1361	1013	1850
10-Mar	4010	6709	4480	1026	1667	1047	1950	1019	2970	3142	1754	1907	1031	1707
17-Mar	3748	6419	3990	1124	2151	1176	2196	1083	3683	3930	1936	1647	996	3161
24-Mar	3340	5796	3448	1209	2510	1477	3034	1123	3052	4391	3221	1971	1001	5030

Week of Water Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
31-Mar	6218	5871	3113	1595	2213	1728	3223	1139	2819	3758	3972	2615	1009	4953
7-Apr	6640	6242	2839	1730	2073	2446	2882	1215	3876	2838	3585	2207	1133	4518
14-Apr	6004	5821	2281	1527	1972	2494	2067	1264	5631	2302	2668	1726	1156	3519
21-Apr	4927	5651	2651	1286	2555	2253	1952	1178	6925	2442	2828	1935	1153	2912
28-Apr	3096	5980	4895	1436	2376	2131	1873	1188	6860	2196	3178	1857	1192	3740
5-May	2947	5598	3286	1408	2058	2398	1638	1439	5352	1974	3270	1986	1563	3773
12-May	3868	4791	2786	1239	2392	2381	1377	1884	5110	2092	2568	2227	1671	3276
19-May	5437	4563	2680	1176	1826	2307	1456	2681	5038	1699	2735	2522	1589	3378
26-May	5781	4210	2295	1207	1421	2034	1373	3127	4587	1311	3008	1933	1709	3612
2-Jun	5510	4592	1903	1146	1399	1904	1288	3021	4150	1155	2790	1498	1541	3557
9-Jun	4904	4538	1729	1215	1379	2036	1240	2267	2926	1229	3200	1530	1666	3322
16-Jun	4241	3485	1620	1135	1334	1791	1347	1821	2293	1386	3076	1840	2199	2789
23-Jun	3861	2547	1491	954	1084	1328	1136	1447	1753	1104	1975	1656	1783	2690
30-Jun	2931	2137	1177	949	950	1062	971	1263	1344	965	1371	1284	1331	2388
7-Jul	2234	1767	1025	965	1002	957	1042	1126	1244	962	1153	1073	1077	1906
14-Jul	1423	1318	1178	1019	1020	973	1029	1013	1153	1060	1074	1061	974	1217
21-Jul	1204	1231	1080	1033	927	978	1016	1004	1073	1054	1007	1050	912	1133
28-Jul	1236	1192	1090	1004	903	914	1046	1005	1066	1103	1085	1042	890	1186
4-Aug	1259	1133	1060	971	998	919	1006	992	941	992	1101	1079	938	1182
11-Aug	1159	1156	1165	1062	935	1056	1069	1052	1038	1063	1164	1126	968	1176
18-Aug	1126	1138	1043	994	887	991	1046	986	1105	1062	1052	1064	896	1099
25-Aug	1138	1147	1034	1056	903	899	1035	994	985	1032	1064	1055	903	1101
1-Sep	1164	1177	1089	1054	920	904	1051	932	1090	1056	1058	1077	895	1052
8-Sep	1198	1146	1164	1072	1026	1007	1011	1003	1109	1053	1010	1126	952	1124
15-Sep	1260	1238	1481	1096	1082	1108	1115	1128	1179	1147	1125	1157	1006	1205
22-Sep	1223	1221	1201	1122	1096	1122	1143	1123	1213	1157	1160	1111	1022	1180
29-Sep	1247	1229	1214	1132	1121	1145	1157	1146	1209	1173	1173	1138	1068	1180

16.2.6 Observed Clear Lake Reservoir end of month surface elevations in feet (Reclamation 2012).

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
2011	4,520.42	4,520.43	4,522.36	4,523.22	4,523.59	4,526.17	4,528.85	4,529.04	4,528.67	4,527.71	4,526.65	4,525.96
2010	4,521.86	4,521.88	4,522.09	4,522.15	4,522.26	4,522.74	4,523.03	4,522.57	4,522.19	4,522.06	4,520.94	4,520.62
2009	4,523.23	4,523.24	4,523.31	4,523.40	4,523.55	4,523.99	4,523.79	4,522.59	4,520.79	4,520.12	4,521.87	4,521.82
2008	4,523.59	4,523.57	4,523.68	4,523.94	4,524.48	4,526.61	4,527.33	4,527.27	4,526.60	4,525.35	4,524.18	4,523.40
2007	4,528.08	4,528.11	4,528.19	4,528.20	4,528.41	4,528.69	4,528.53	4,527.73	4,526.76	4,525.63	4,524.41	4,523.77
2006	4,521.68	4,522.18	4,525.30	4,527.12	4,528.23	4,529.86	4,532.32	4,532.08	4,531.30	4,530.27	4,529.14	4,528.31
2005	4,521.87	4,521.89	4,522.09	4,522.39	4,522.69	4,522.72	4,523.26	4,524.76	4,524.13	4,522.82	4,521.72	4,521.79
2004	4,521.86	4,522.07	4,522.38	4,522.82	4,524.60	4,526.29	4,526.31	4,525.69	4,524.72	4,523.42	4,520.62	4,518.34
2003	4,524.02	4,524.00	4,524.40	4,524.70	4,524.96	4,525.32	4,526.04	4,526.18	4,525.07	4,523.85	4,520.98	4,522.25
2002	4,525.60	4,525.86	4,526.52	4,526.90	4,527.35	4,527.89	4,528.51	4,528.16	4,527.19	4,526.13	4,524.90	4,524.15
2001	4,531.33	4,531.46	4,531.48	4,531.45	4,531.51	4,531.63	4,531.52	4,530.54	4,529.20	4,527.98	4,526.65	4,525.75
2000	4,534.17	4,534.07	4,534.06	4,534.45	4,535.02	4,536.12	4,536.49	4,535.98	4,535.06	4,534.06	4,532.99	4,531.54
1999	4,535.21	4,535.63	4,536.16	4,536.52	4,536.82	4,537.84	4,537.88	4,537.62	4,536.90	4,535.94	4,535.04	4,534.35
1998	4,534.35	4,534.32	4,534.36	4,536.02	4,536.86	4,538.57	4,538.48	4,538.53	4,538.30	4,537.39	4,536.34	4,535.64
1997	4,533.78	4,533.80	4,535.90	4,537.67	4,537.89	4,538.20	4,538.30	4,537.81	4,537.00	4,536.20	4,535.20	4,534.60
1996	4,529.94	4,530.00	4,530.45	4,531.26	4,535.62	4,537.13	4,537.45	4,537.40	4,536.64	4,535.65	4,534.71	4,534.00
1995	4,521.54	4,521.65	4,521.96	4,525.89	4,527.49	4,531.23	4,532.80	4,533.46	4,532.98	4,532.00	4,531.01	4,530.24
1994	4,526.04	4,525.96	4,526.05	4,526.09	4,526.20	4,526.30	4,525.84	4,525.39	4,524.49	4,523.16	4,521.43	4,521.70
1993	4,519.30	4,519.29	4,519.35	4,519.40	4,521.46	4,527.98	4,529.40	4,529.12	4,528.54	4,527.63	4,526.86	4,526.16
1992	4,522.50	4,522.51	4,522.80	4,522.85	4,523.00	4,522.84	4,522.75	4,521.77	4,521.18	4,520.44	4,519.82	4,519.42
1991	4,526.78	4,526.76	4,526.70	4,526.98	4,527.00	4,527.10	4,526.90	4,526.42	4,525.65	4,524.45	4,523.52	4,522.75
1990	4,531.82	4,530.80	4,530.82	4,530.95	4,531.05	4,531.54	4,531.24	4,530.55	4,529.90	4,528.78	4,527.74	4,527.08
1989	4,528.30	4,528.30	4,528.34	4,528.67	4,529.00	4,533.88	4,534.82	4,534.40	4,533.68	4,532.47	4,531.54	4,531.00
1988	4,531.17	4,531.10	4,531.30	4,531.42	4,532.00	4,532.68	4,532.54	4,532.18	4,531.20	4,530.20	4,529.13	4,528.30
1987	4,534.97	4,534.85	4,534.83	4,535.08	4,535.20	4,535.66	4,535.35	4,534.50	4,533.85	4,533.05	4,532.09	4,531.41
1986	4,534.11	4,534.20	4,534.14	4,534.40	4,537.80	4,539.55	4,539.27	4,538.78	4,537.85	4,536.76	4,535.63	4,535.14
1985	4,536.41	4,536.86	4,536.88	4,536.88	4,537.45	4,538.24	4,538.52	4,537.85	4,536.85	4,535.65	4,534.64	4,534.30
1984	4,537.02	4,537.05	4,539.43	4,539.60	4,540.11	4,541.63	4,542.28	4,541.89	4,541.27	4,540.33	4,538.97	4,537.86
1983	4,532.78	4,532.85	4,533.02	4,534.54	4,536.42	4,539.26	4,540.40	4,540.72	4,540.00	4,538.94	4,538.00	4,537.27
1982	4,524.42	4,525.95	4,528.48	4,529.02	4,532.40	4,533.70	4,536.60	4,536.14	4,535.45	4,534.65	4,533.50	4,532.71
1981	4,527.20	4,527.26	4,527.21	4,527.32	4,527.73	4,528.70	4,528.85	4,528.27	4,527.42	4,526.24	4,525.10	4,524.36
1980	4,524.33	4,524.55	4,524.85	4,527.26	4,529.66	4,530.70	4,530.94	4,530.61	4,530.30	4,529.05	4,528.10	4,527.41

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
1979	4,526.96	4,527.00	4,527.00	4,527.16	4,527.40	4,528.60	4,528.78	4,528.12	4,527.32	4,526.06	4,525.10	4,524.38
1978	4,525.95	4,525.96	4,526.58	4,528.10	4,528.55	4,529.57	4,531.09	4,530.80	4,529.90	4,528.86	4,527.88	4,527.20
1977	4,530.22	4,530.15	4,530.17	4,530.16	4,530.20	4,530.17	4,529.60	4,529.34	4,528.54	4,527.43	4,526.58	4,526.39
1976	4,533.60	4,533.57	4,533.61	4,533.68	4,533.70	4,534.27	4,534.24	4,533.35	4,532.47	4,531.45	4,531.20	4,530.37
1975	4,533.10	4,533.06	4,533.10	4,533.26	4,533.74	4,535.82	4,536.86	4,537.53	4,536.55	4,535.55	4,534.63	4,533.77
1974	4,530.73	4,531.16	4,532.34	4,534.00	4,534.18	4,536.90	4,537.94	4,537.27	4,536.25	4,535.30	4,534.34	4,533.41
1973	4,533.48	4,533.51	4,533.78	4,535.15	4,534.70	4,535.24	4,535.34	4,534.70	4,533.76	4,532.62	4,531.46	4,530.88
1972	4,533.17	4,533.18	4,533.28	4,534.33	4,535.82	4,538.92	4,539.14	4,538.40	4,537.30	4,535.84	4,534.52	4,533.56
1971	4,532.60	4,532.96	4,533.78	4,535.44	4,536.02	4,538.48	4,539.26	4,539.10	4,538.55	4,537.40	4,535.63	4,533.58
1970	4,531.23	4,531.20	4,531.97	4,535.82	4,536.50	4,537.45	4,537.15	4,536.50	4,535.84	4,534.70	4,533.65	4,532.86
1969	4,525.72	4,525.82	4,526.80	4,528.60	4,529.82	4,531.33	4,535.52	4,534.95	4,534.26	4,533.36	4,532.14	4,531.37
1968	4,528.88	4,528.80	4,528.79	4,528.83	4,530.31	4,530.60	4,530.07	4,529.51	4,528.60	4,527.23	4,526.58	4,525.82
1967	4,527.05	4,527.31	4,528.20	4,528.56	4,529.32	4,530.60	4,531.52	4,532.60	4,532.00	4,530.90	4,529.86	4,529.08
1966	4,530.47	4,530.55	4,530.50	4,530.62	4,530.70	4,531.63	4,531.70	4,531.12	4,530.27	4,529.05	4,527.90	4,527.34
1965	4,524.20	4,524.24	4,527.80	4,531.20	4,533.00	4,533.80	4,534.38	4,533.65	4,533.20	4,532.20	4,531.45	4,530.72
1964	4,524.00	4,524.05	4,524.15	4,524.30	4,524.30	4,524.90	4,527.86	4,527.40	4,527.34	4,526.20	4,525.14	4,524.45
1963	4,524.33	4,524.50	4,525.23	4,525.26	4,526.35	4,526.57	4,527.52	4,527.70	4,526.70	4,525.70	4,524.70	4,524.12
1962	4,521.33	4,521.47	4,521.70	4,521.87	4,523.37	4,524.25	4,525.50	4,525.10	4,524.08	4,522.88	4,521.90	4,521.28
1961	4,524.60	4,524.63	4,524.99	4,524.97	4,525.43	4,525.78	4,525.63	4,525.28	4,524.40	4,523.08	4,522.16	4,521.44
1960	4,527.85	4,527.77	4,527.76	4,527.81	4,528.08	4,528.85	4,529.10	4,528.86	4,527.83	4,526.48	4,525.49	4,524.80
1959	4,533.41	4,533.35	4,533.38	4,533.49	4,533.60	4,533.53	4,533.04	4,532.44	4,531.34	4,530.10	4,529.03	4,528.15
1958	4,533.42	4,533.70	4,534.30	4,534.78	4,538.11	4,539.05	4,540.72	4,540.14	4,538.90	4,537.50	4,535.90	4,534.51
1957	4,534.98	4,533.80	4,534.28	4,534.30	4,536.12	4,538.31	4,538.26	4,537.80	4,536.62	4,535.36	4,534.20	4,533.42
1956	4,527.30	4,527.52	4,530.83	4,535.13	4,536.03	4,539.73	4,541.61	4,541.21	4,540.04	4,538.45	4,537.03	4,535.81
1955	4,530.51	4,530.57	4,530.60	4,530.66	4,530.78	4,531.36	4,532.10	4,531.36	4,530.44	4,529.36	4,528.36	4,527.50
1954	4,531.37	4,531.50	4,531.80	4,531.96	4,533.45	4,535.10	4,535.33	4,534.49	4,533.90	4,532.69	4,531.64	4,530.86
1953	4,529.37	4,529.22	4,529.50	4,532.09	4,532.81	4,533.39	4,533.81	4,534.60	4,534.52	4,533.32	4,532.31	4,531.61
1952	4,522.58	4,522.54	4,522.93	4,523.25	4,523.97	4,527.59	4,533.14	4,533.00	4,532.23	4,531.38	4,530.37	4,529.68
1951	4,523.87	4,523.87	4,524.40	4,524.59	4,525.93	4,526.70	4,527.02	4,526.84	4,525.63	4,524.34	4,523.31	4,522.57
1950	4,524.60	4,524.57	4,524.56	4,524.75	4,525.81	4,527.21	4,527.95	4,527.37	4,526.67	4,525.46	4,524.47	4,523.88
1949	4,526.36	4,526.28	4,526.44	4,526.50	4,526.64	4,528.36	4,528.95	4,528.49	4,527.62	4,526.47	4,525.39	4,524.77
1948	4,526.71	4,526.66	4,526.67	4,527.00	4,527.08	4,527.37	4,528.57	4,529.31	4,528.87	4,527.87	4,526.99	4,526.51
1947	4,529.65	4,529.71	4,529.84	4,529.85	4,530.23	4,530.95	4,530.66	4,529.92	4,529.44	4,528.33	4,527.46	4,526.84

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
1946	4,530.92	4,531.19	4,531.51	4,532.13	4,531.75	4,533.47	4,534.14	4,533.47	4,532.59	4,531.62	4,530.65	4,529.93
1945	4,530.44	4,530.67	4,530.78	4,531.02	4,533.35	4,533.54	4,533.95	4,534.07	4,533.91	4,532.44	4,531.89	4,531.06
1944	4,534.00	4,533.97	4,533.94	4,533.96	4,533.98	4,534.07	4,534.37	4,533.72	4,533.25	4,532.22	4,531.27	4,530.60
1943	4,531.50	4,531.53	4,531.80	4,532.11	4,532.50	4,536.92	4,537.81	4,537.62	4,536.91	4,535.94	4,534.96	4,534.27
1942	4,529.08	4,529.09	4,530.26	4,531.99	4,533.43	4,534.45	4,534.93	4,535.10	4,534.37	4,533.31	4,532.38	4,531.77
1941	4,529.51	4,529.47	4,529.65	4,529.95	4,531.75	4,532.37	4,532.28	4,531.88	4,531.30	4,530.38	4,529.70	4,529.21
1940	4,527.61	4,527.54	4,527.91	4,528.92	4,531.63	4,533.27	4,533.70	4,533.05	4,532.00	4,531.00	4,530.03	4,529.63
1939	4,531.11	4,531.10	4,531.05	4,531.08	4,531.08	4,532.00	4,531.65	4,530.91	4,530.04	4,529.12	4,528.17	4,527.78
1938	4,521.60	4,522.00	4,524.65	4,524.90	4,525.65	4,530.58	4,534.85	4,534.80	4,533.80	4,532.95	4,531.95	4,531.32
1937	4,520.90	4,520.80	4,520.80	4,521.00	4,521.17	4,525.70	4,525.05	4,524.40	4,523.80	4,522.90	4,522.10	4,521.60
1936	4,518.50	4,518.50	4,518.70	4,519.45	4,521.60	4,523.30	4,524.35	4,524.00	4,523.36	4,522.40	4,521.60	4,521.15
1935	4,514.40	4,514.85	4,515.23	4,515.30	4,516.30	4,517.50	4,522.10	4,521.60	4,520.70	4,519.90	4,519.10	4,518.60
1934	4,517.70	4,517.65	4,517.90	4,518.05	4,518.33	4,518.10	4,517.67	4,517.00	4,516.41	4,515.62	4,515.00	4,514.50
1933	4,519.75	4,519.70	4,519.70	4,519.80	4,519.90	4,520.80	4,521.40	4,521.35	4,520.15	4,519.00	4,518.12	4,517.70
1932	4,517.05	4,517.08	4,517.30	4,517.45	4,517.53	4,523.60	4,523.65	4,523.25	4,522.32	4,521.40	4,520.50	4,519.84
1931	4,521.82	4,521.81	4,521.80	4,521.80	4,521.80	4,521.60	4,521.35	4,520.60	4,519.60	4,518.25	4,517.60	4,517.20
1930	4,522.88	4,522.84	4,523.02	4,523.22	4,524.95	4,525.85	4,525.60	4,524.90	4,523.76	4,522.63	4,522.04	4,521.84
1929	4,526.35	4,526.40	4,526.45	4,526.58	4,526.77	4,527.14	4,527.50	4,526.66	4,525.94	4,524.74	4,523.60	4,522.96
1928	4,525.52	4,525.88	4,526.07	4,526.07	4,526.68	4,527.62	4,529.96	4,530.65	4,530.00	4,529.03	4,528.03	4,527.15
1927	4,522.66	4,523.30	4,523.55	4,524.02	4,525.35	4,527.18	4,528.75	4,528.75	4,527.97	4,527.00	4,526.10	4,525.64
1926	4,526.71	4,526.75	4,526.83	4,526.83	4,527.16	4,527.10	4,526.71	4,526.00	4,524.86	4,523.81	4,523.00	4,522.66
1925	4,528.30	4,528.31	4,528.46	4,528.69	4,529.60	4,529.75	4,529.64	4,529.39	4,528.93	4,528.00	4,527.20	4,526.86
1924	4,534.30	4,534.20	4,534.16	4,534.19	4,534.42	4,534.23	4,533.92	4,533.28	4,532.39	4,531.38	4,530.20	4,529.06
1923	4,536.32	4,536.03	4,536.03	4,536.17	4,536.27	4,536.71	4,537.00	4,536.56	4,536.10	4,535.79	4,534.99	4,534.48
1922	4,535.00	4,534.95	4,534.91	4,535.00	4,535.13	4,535.74	4,538.80	4,538.93	4,538.31	4,537.61	4,536.99	4,536.60
1921	4,531.47	4,531.65	4,532.02	4,533.70	4,535.60	4,537.74	4,538.18	4,537.86	4,537.44	4,536.54	4,535.94	4,535.32
1920	4,534.00	4,533.90	4,533.90	4,533.90	4,533.83	4,534.01	4,534.22	4,533.75	4,533.17	4,532.52	4,531.94	4,531.55
1919	4,533.48	4,533.45	4,533.45	4,534.45	4,533.97	4,535.12	4,537.40	4,536.80	4,536.02	4,535.30	4,534.60	4,534.20
1918	4,536.48	4,536.38	4,536.25	4,536.20	4,536.18	4,536.80	4,536.59	4,536.10	4,535.37	4,534.60	4,533.98	4,533.70
1917	4,532.70	4,532.66	4,532.12	4,532.25	4,532.25	4,533.70	4,539.04	4,539.60	4,538.84	4,538.04	4,537.50	4,536.81
1916	4,531.85	4,531.90	4,531.88	4,532.02	4,533.45	4,535.15	4,535.60	4,535.20	4,534.65	4,534.05	4,533.35	4,532.95
1915	4,533.27	4,533.23	4,533.20	4,533.20	4,534.00	4,535.00	4,534.85	4,534.65	4,533.97	4,533.30	4,532.68	4,532.15
1914	4,529.80	4,529.75	4,529.75	4,531.30	4,532.15	4,535.80	4,536.24	4,535.83	4,535.44	4,534.77	4,534.00	4,533.40

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
1913	4,529.25	4,529.20	4,529.25	4,529.30	4,539.30	4,529.85	4,531.95	4,531.85	4,531.30	4,531.10	4,530.65	4,530.05
1912	4,529.75	4,529.65	4,529.80	4,530.00	4,530.50	4,530.80	4,531.30	4,531.40	4,531.10	4,530.65	4,530.20	4,529.55
1911	4,524.12	4,524.24	4,525.90	4,526.15	4,526.35	4,529.30	4,532.35	4,532.05	4,531.75	4,531.10	4,530.55	4,530.00
1910	NA	NA	NA	4,523.60	4,525.40	4,527.40	4,527.10	4,526.70	4,526.00	4,525.40	4,524.60	4,524.28
1909	4,529.00	4,528.90	4,528.85	4,529.80	4,530.30	4,531.35	4,532.05	4,531.45	4,530.55	4,529.35	4,528.30	4,527.65
1908	4,532.70	4,532.60	4,532.75	4,533.20	4,533.25	4,533.60	4,533.60	4,533.00	4,531.95	4,530.75	4,529.70	4,529.10
1907	4,525.85	4,525.80	4,526.25	4,527.00	4,530.00	4,533.90	4,536.50	4,526.25	4,535.50	4,534.30	4,533.25	4,532.75
1906	4,523.85	4,523.80	4,523.80	4,523.80	4,524.15	4,526.75	4,529.95	4,529.80	4,529.00	4,527.80	4,526.65	4,526.00
1905	4,522.10	4,522.20	4,522.30	4,522.85	4,523.65	4,524.45	4,524.75	4,524.70	4,524.70	4,524.40	4,524.10	4,523.95

16.2.7 Observed Gerber Reservoir end of month surface elevations in feet (Reclamation 2012).

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
2011	4,803.18	4,803.22	4,809.08	4,814.44	4,815.22	4,821.88	4,830.13	4,830.10	4,828.25	4,825.39	4,822.56	4,820.12
2010	4,812.24	4,812.07	4,812.80	4,813.34	4,815.24	4,816.12	4,817.79	4,817.46	4,815.30	4,811.40	4,807.20	4,803.28
2009	4,820.56	4,820.52	4,820.87	4,820.74	4,821.68	4,824.58	4,825.00	4,823.49	4,821.92	4,818.72	4,815.56	4,812.40
2008	4,819.80	4,819.81	4,819.96	4,820.37	4,820.65	4,826.60	4,831.86	4,830.70	4,828.98	4,826.18	4,823.33	4,820.81
2007	4,824.23	4,824.50	4,825.92	4,825.98	4,828.30	4,832.27	4,832.60	4,830.58	4,828.06	4,825.25	4,822.27	4,819.82
2006	4,807.44	4,809.23	4,820.64	4,826.60	4,831.32	4,835.88	4,836.22	4,834.60	4,832.57	4,829.76	4,827.06	4,824.57
2005	4,805.69	4,805.68	4,808.30	4,808.30	4,810.72	4,812.04	4,813.94	4,821.27	4,819.14	4,815.37	4,811.34	4,807.54
2004	4,808.25	4,808.28	4,808.99	4,810.41	4,815.39	4,822.44	4,822.33	4,820.15	4,817.26	4,813.52	4,809.36	4,805.98
2003	4,808.26	4,808.35	4,809.26	4,813.21	4,814.12	4,816.69	4,821.17	4,822.45	4,819.08	4,815.40	4,811.83	4,808.61
2002	4,810.59	4,810.86	4,811.35	4,816.32	4,818.32	4,822.69	4,824.50	4,822.84	4,819.76	4,816.10	4,812.30	4,808.50
2001	4,823.07	4,823.13	4,823.19	4,823.21	4,823.41	4,825.38	4,825.75	4,823.01	4,819.96	4,816.85	4,813.28	4,810.87
2000	4,823.80	4,823.56	4,823.68	4,825.50	4,828.48	4,832.54	4,835.00	4,833.46	4,830.73	4,827.98	4,825.11	4,823.40
1999	4,827.45	4,829.68	4,830.94	4,832.38	4,830.70	4,831.14	4,834.24	4,833.97	4,831.84	4,828.83	4,826.20	4,823.80
1998	4,824.40	4,824.42	4,824.56	4,830.82	4,833.76	4,836.19	4,835.65	4,836.29	4,835.16	4,832.68	4,830.39	4,828.00
1997	4,826.18	4,826.60	4,834.60	4,834.18	4,834.10	4,835.56	4,835.55	4,833.64	4,831.62	4,828.96	4,826.51	4,824.36
1996	4,825.39	4,825.40	4,827.50	4,829.67	4,835.04	4,835.88	4,835.83	4,835.72	4,833.54	4,830.97	4,828.42	4,826.36
1995	4,806.59	4,806.74	4,807.08	4,816.63	4,822.02	4,832.16	4,835.91	4,835.13	4,833.88	4,831.16	4,828.27	4,825.70
1994	4,821.96	4,821.96	4,822.20	4,822.32	4,822.94	4,823.30	4,822.48	4,820.80	4,817.81	4,814.08	4,810.16	4,806.78
1993	4,796.62	4,796.62	4,797.06	4,798.79	4,802.24	4,828.00	4,831.92	4,830.34	4,829.60	4,826.84	4,824.49	4,822.04
1992	4,797.98	4,797.96	4,798.04	4,798.18	4,800.74	4,801.28	4,801.14	4,798.86	4,798.36	4,797.73	4,797.01	4,796.52
1991	4,804.38	4,804.32	4,804.40	4,804.54	4,804.82	4,804.18	4,808.26	4,808.10	4,803.60	4,799.22	4,798.60	4,798.08
1990	4,815.18	4,815.16	4,815.20	4,816.58	4,817.48	4,821.33	4,821.20	4,818.94	4,816.12	4,812.25	4,808.70	4,804.56
1989	4,802.20	4,803.98	4,804.30	4,804.40	4,805.42	4,826.42	4,828.66	4,827.00	4,824.18	4,820.81	4,818.00	4,815.26
1988	4,813.24	4,813.18	4,813.54	4,814.00	4,815.80	4,819.12	4,819.53	4,817.53	4,815.00	4,810.95	4,806.90	4,802.40
1987	4,822.95	4,822.88	4,823.00	4,823.10	4,824.78	4,827.90	4,827.18	4,824.65	4,822.30	4,819.68	4,816.32	4,813.47
1986	4,823.47	4,823.51	4,823.58	4,825.91	4,834.07	4,835.60	4,834.93	4,833.32	4,830.58	4,827.68	4,824.54	4,823.10
1985	4,825.85	4,828.12	4,828.50	4,828.37	4,828.90	4,833.88	4,835.49	4,833.58	4,830.98	4,827.95	4,824.90	4,823.62
1984	4,826.26	4,826.92	4,826.82	4,824.64	4,826.50	4,836.19	4,835.80	4,834.85	4,833.15	4,830.25	4,827.68	4,825.48
1983	4,826.07	4,826.31	4,827.60	4,829.55	4,830.90	4,834.40	4,836.48	4,835.04	4,833.18	4,830.95	4,828.88	4,826.88
1982	4,804.44	4,811.50	4,821.60	4,822.20	4,833.50	4,835.85	4,835.90	4,834.58	4,832.76	4,830.70	4,827.94	4,825.93
1981	4,814.15	4,814.18	4,814.68	4,814.80	4,818.00	4,820.82	4,821.40	4,819.10	4,816.20	4,812.40	4,807.98	4,804.24
1980	4,805.72	4,807.30	4,809.00	4,817.26	4,824.18	4,826.15	4,827.05	4,825.00	4,822.80	4,819.80	4,816.50	4,814.23

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
1979	4,815.44	4,815.46	4,815.47	4,816.82	4,817.82	4,822.06	4,822.00	4,820.18	4,816.46	4,812.30	4,809.00	4,805.64
1978	4,802.42	4,804.40	4,809.17	4,816.38	4,819.01	4,824.76	4,828.17	4,827.00	4,824.10	4,821.08	4,817.98	4,815.70
1977	4,817.45	4,817.36	4,817.40	4,817.40	4,817.50	4,817.70	4,816.52	4,815.17	4,812.14	4,807.90	4,804.12	4,802.50
1976	4,822.66	4,822.80	4,823.63	4,823.70	4,824.69	4,828.38	4,830.25	4,827.30	4,824.52	4,821.15	4,820.48	4,817.76
1975	4,820.08	4,820.10	4,820.49	4,820.68	4,821.34	4,825.47	4,833.58	4,834.87	4,831.68	4,828.62	4,825.58	4,822.70
1974	4,812.98	4,815.62	4,820.00	4,824.17	4,824.77	4,833.27	4,834.84	4,832.90	4,829.73	4,827.04	4,823.89	4,820.76
1973	4,821.20	4,821.43	4,822.99	4,824.02	4,825.56	4,828.32	4,829.26	4,826.56	4,823.14	4,819.34	4,815.46	4,813.05
1972	4,824.20	4,824.41	4,824.70	4,826.55	4,833.04	4,835.07	4,835.50	4,833.15	4,830.22	4,826.68	4,823.39	4,821.22
1971	4,821.49	4,823.04	4,825.39	4,829.46	4,831.46	4,834.49	4,835.50	4,834.86	4,832.96	4,830.21	4,826.94	4,824.38
1970	4,821.80	4,821.81	4,824.60	4,832.08	4,832.03	4,835.00	4,834.59	4,832.57	4,830.03	4,826.78	4,823.64	4,821.63
1969	4,809.20	4,809.74	4,811.45	4,813.95	4,815.95	4,821.84	4,834.39	4,832.56	4,830.70	4,827.56	4,824.29	4,822.06
1968	4,820.62	4,820.50	4,820.62	4,820.85	4,825.65	4,825.91	4,824.71	4,822.84	4,819.52	4,815.48	4,812.90	4,809.64
1967	4,814.62	4,815.24	4,817.83	4,818.90	4,821.25	4,826.07	4,829.68	4,832.07	4,829.70	4,826.50	4,823.32	4,820.88
1966	4,822.70	4,822.83	4,822.85	4,823.14	4,823.21	4,828.30	4,828.94	4,826.32	4,823.91	4,820.80	4,817.50	4,815.38
1965	4,816.58	4,816.85	4,831.40	4,829.70	4,829.02	4,831.75	4,833.95	4,831.70	4,830.00	4,826.76	4,825.00	4,822.90
1964	4,817.26	4,817.57	4,817.66	4,818.10	4,818.12	4,818.80	4,827.70	4,825.90	4,826.10	4,822.70	4,819.70	4,817.20
1963	4,809.67	4,810.50	4,814.38	4,814.80	4,819.92	4,821.30	4,827.30	4,828.00	4,825.45	4,822.65	4,819.65	4,817.90
1962	4,794.27	4,795.93	4,798.80	4,799.14	4,803.80	4,809.00	4,818.87	4,817.47	4,814.10	4,809.85	4,805.60	4,801.05
1961	4,796.53	4,797.17	4,801.25	4,802.34	4,807.64	4,811.30	4,812.37	4,810.35	4,807.88	4,804.13	4,801.24	4,794.47
1960	4,801.01	4,800.56	4,800.52	4,800.64	4,805.36	4,813.50	4,815.07	4,815.26	4,811.74	4,806.92	4,802.52	4,796.98
1959	4,820.80	4,820.64	4,820.63	4,821.71	4,822.74	4,824.22	4,822.88	4,820.35	4,815.76	4,810.25	4,805.51	4,802.16
1958	4,821.05	4,822.75	4,825.00	4,821.05	4,822.75	4,825.00	4,825.70	4,834.82	4,833.38	4,835.30	4,833.25	4,831.24
1957	4,820.82	4,821.46	4,823.06	4,823.20	4,829.65	4,833.55	4,834.97	4,834.30	4,830.92	4,827.06	4,823.30	4,820.52
1956	4,803.38	4,804.90	4,821.50	4,825.57	4,823.44	4,830.74	4,832.32	4,832.90	4,830.30	4,826.72	4,823.39	4,820.62
1955	4,814.20	4,814.29	4,814.27	4,814.39	4,814.46	4,818.07	4,821.42	4,819.47	4,815.51	4,811.38	4,816.58	4,804.02
1954	4,822.00	4,822.81	4,822.29	4,821.03	4,823.05	4,829.63	4,831.64	4,828.39	4,825.88	4,821.68	4,817.84	4,815.25
1953	4,818.87	4,818.77	4,819.24	4,825.25	4,827.08	4,830.77	4,831.94	4,833.07	4,832.19	4,828.25	4,824.84	4,822.62
1952	4,810.49	4,810.77	4,812.26	4,812.75	4,811.60	4,813.97	4,831.86	4,830.96	4,828.60	4,825.34	4,821.99	4,819.66
1951	4,806.57	4,807.41	4,813.10	4,813.56	4,820.09	4,824.98	4,825.72	4,825.24	4,821.44	4,817.19	4,813.65	4,810.44
1950	4,806.88	4,806.92	4,807.03	4,809.10	4,814.13	4,819.88	4,823.04	4,820.98	4,818.00	4,813.14	4,809.01	4,806.31
1949	4,810.17	4,810.30	4,810.66	4,808.67	4,807.79	4,816.60	4,821.81	4,820.50	4,817.64	4,813.48	4,809.75	4,806.89
1948	4,808.31	4,808.35	4,808.46	4,811.72	4,812.74	4,815.11	4,819.50	4,820.47	4,818.88	4,815.14	4,812.07	4,810.33

Water Year	October	November	December	January	February	March	April	May	June	July	August	September
1947	4,813.64	4,813.94	4,814.86	4,815.19	4,818.07	4,820.06	4,820.09	4,817.78	4,816.67	4,812.98	4,809.76	4,808.42
1946	4,821.02	4,821.76	4,822.65	4,816.13	4,812.71	4,823.19	4,827.81	4,825.45	4,822.57	4,819.17	4,815.97	4,813.94
1945	4,813.96	4,814.36	4,815.39	4,817.11	4,823.28	4,825.76	4,828.83	4,830.78	4,829.62	4,826.42	4,823.31	4,821.24
1944	4,820.53	4,820.61	4,820.66	4,820.79	4,820.98	4,823.90	4,824.88	4,822.55	4,821.54	4,818.79	4,815.94	4,814.26
1943	4,819.42	4,820.94	4,822.45	4,818.96	4,812.08	4,830.35	4,830.08	4,829.56	4,828.04	4,825.39	4,822.66	4,820.99
1942	4,822.28	4,821.88	4,819.86	4,817.75	4,820.88	4,826.97	4,829.10	4,827.01	4,824.55	4,822.90	4,820.73	4,818.50
1941	4,798.22	4,805.50	4,808.86	4,811.93	4,816.80	4,825.55	4,830.85	4,830.88	4,829.56	4,827.96	4,826.38	4,824.45
1940	4,804.98	4,804.95	4,805.41	4,805.46	4,808.55	4,809.12	4,808.80	4,806.90	4,804.30	4,802.06	4,800.15	4,798.45
1939	4,817.55	4,817.68	4,820.48	4,820.36	4,819.94	4,825.09	4,827.32	4,828.67	4,826.74	4,823.98	4,821.54	4,820.02
1938	4,819.55	4,819.65	4,820.28	4,820.68	4,822.98	4,826.49	4,826.55	4,825.00	4,823.28	4,820.69	4,818.72	4,817.64
1937	4,812.39	4,812.30	4,814.18	4,817.85	4,825.66	4,831.60	4,830.13	4,828.16	4,825.55	4,822.83	4,820.54	4,819.60
1936	4,817.05	4,817.23	4,817.65	4,817.74	4,817.90	4,823.98	4,823.45	4,821.20	4,818.70	4,816.25	4,813.66	4,812.53
1935	4,818.20	4,819.05	4,821.47	4,820.77	4,817.42	4,818.12	4,831.58	4,826.93	4,824.55	4,821.65	4,819.07	4,817.31
1934	4,818.04	4,817.74	4,817.81	4,817.90	4,817.60	4,820.96	4,829.46	4,828.11	4,826.01	4,823.24	4,820.80	4,818.89
1933	4,816.52	4,816.51	4,816.64	4,817.44	4,820.30	4,828.11	4,830.30	4,827.28	4,824.50	4,821.92	4,820.00	4,818.72
1932	4,803.26	4,804.12	4,805.79	4,806.08	4,808.28	4,813.66	4,824.40	4,823.63	4,821.57	4,819.87	4,818.13	4,816.78
1931	4,811.52	4,811.40	4,811.63	4,813.20	4,814.49	4,814.95	4,814.25	4,812.35	4,810.22	4,807.39	4,804.98	4,803.35
1930	4,811.18	4,811.13	4,811.17	4,811.34	4,811.40	4,813.05	4,817.54	4,818.85	4,816.70	4,814.58	4,812.79	4,811.65
1929	4,794.81	4,795.11	4,795.29	4,795.71	4,796.09	4,817.58	4,819.11	4,818.49	4,816.96	4,814.82	4,812.97	4,811.68
1928	4,806.99	4,807.02	4,807.04	4,807.35	4,807.70	4,809.13	4,809.00	4,807.39	4,804.31	4,801.68	4,798.80	4,795.77
1927	4,811.16	4,811.00	4,811.80	4,812.04	4,816.85	4,818.63	4,818.70	4,817.08	4,814.58	4,811.82	4,808.90	4,807.16
1926	4,816.99	4,816.11	4,816.25	4,816.36	4,816.44	4,819.54	4,820.97	4,819.34	4,817.28	4,814.88	4,812.92	4,811.65
1925	NA	NA	NA	4,797.70	4,805.00	4,806.50	4,808.90	4,809.20	4,808.50	4,806.90	4,805.80	4,805.10

16.3 Appendix C: Description of Restoration Project Types

Habitat restoration projects authorized through the Program will be designed and implemented consistent with techniques and minimization measures presented in California Department of Fish and Wildlife's (CDFW) *California Salmonid Stream Habitat Restoration Manual, Fourth Edition, Volume II* with four chapters *(Part IX: Fish Passage Evaluation at Stream Crossings, Part XI: Riparian Habitat Restoration, and Part XII:* ***Fish Passage Design and Implementation***; Flosi et al. 2010, referred to as the Restoration Manual). The Program requires avoidance and minimization practices for all projects to reduce the potential for ancillary effects to listed species and other riparian and aquatic species. These measures are described in subsection *D. Sideboards, Minimization Measures, and other Requirements.* Program activities are as follows:

1. Instream Habitat Structures and Improvements

Instream habitat structures and improvements are intended to provide predator escape and resting cover, increase spawning habitat, improve migration corridors, improve pool to riffle ratios, and add habitat complexity and diversity. Specific techniques for instream habitat improvement include: (1) placement of cover structures (divide logs, engineered log jams, digger logs, spider logs; and log, root wad, and boulder combinations), boulder structures (boulder weirs, vortex boulder weirs, boulder clusters, and single and opposing boulder-wing-deflectors), (2) log structures (log weirs, upsurge weirs, single and opposing log-wing-deflectors, engineered log jams, and Hewitt ramps), and (3) placement of imported spawning gravel. Implementation of these types of projects may require the use of heavy equipment (*e.g.*, self-propelled logging yarders, excavators, backhoes, helicopters), however, hand labor will be used when possible. Large woody debris (LWD) may also be placed in the stream channel to enhance pool formation and increase stream channel complexity. Projects will include both anchored and unanchored logs, depending on site conditions and wood availability.

2. Barrier Modification for Fish Passage Improvement

Barrier modification projects are intended to improve salmonid fish passage by (1) providing access to upstream habitat, (2) improving access to habitat, and (3) increasing the duration of accessibility (both within and between years). Projects may include those that improve fish passage through existing culverts, bridges, and paved and unpaved fords through replacement, removal, or retrofitting. In particular, these practices may include the use of gradient control weirs upstream or downstream of barriers to control water velocity, water surface elevation, or provide sufficient pool habitat to facilitate jumps, or interior baffles or weirs to mediate velocity and the increased water depth. Weirs may also be used to improve passage in flood control channels (particularly concrete lined channels). The Program also includes log jam modifications to facilitate juvenile and adult fish passage. Implementing these types of projects may require the use of heavy equipment (*e.g.*, self-propelled logging yarders, mechanical excavators, backhoes), however, hand labor will be used when possible.

Part IX of the CDFW Restoration Manual, entitled *Fish Passage Evaluation at Stream Crossings*, provides consistent methods for evaluating fish passage through culverts at stream crossings, and will aid in assessing fish passage through other types of stream crossings, such as bridges and paved or hardened fords. The objectives of Part IX are to provide the user with consistent methods for evaluating salmonid passage though stream crossings, ranking criteria for prioritizing stream crossing sites for treatment, treatment options to provide unimpeded fish passage, a stream crossing remediation project checklist, guidance measures to minimize impacts during stream crossing remediation construction, and methods for monitoring the effectiveness of corrective treatments.

The chapter in the CDFW Restoration Manual (Part XII), entitled *Fish Passage Design and Implementation,* provides technical guidance for the design of fish passage projects at stream crossings, small dams and water diversion structures. Part XII is intended to:

> guide designers through the general process of selecting a design approach for passage improvement. It provides concepts, a design framework, and procedures to design stream crossings and fishways that satisfy ecological objectives, including: efficient and safe passage of all aquatic organisms and life stages, continuity of geomorphic processes such as the movement of debris and sediment, accommodation of behavior and swimming ability of organisms to be passed, diversity of physical and hydraulic conditions leading to high diversity of passage opportunities, projects that are self-sustaining and durable, and passage of terrestrial organisms that move within the riparian corridor.

Where there is an opportunity to protect salmonids, additional site-specific criteria may be appropriate.

3. Bioengineering and Riparian Habitat Restoration

These projects are intended to improve salmonid habitat through increased stream shading intended to lower stream temperatures, increase future recruitment of LWD to streams, and increase bank stability and invertebrate production. Riparian habitat restoration projects will aid in the restoration of riparian habitat by increasing the number of plants and plant groupings, and will include the following types of projects: natural regeneration, livestock exclusionary fencing, bioengineering, and revegetation. Part XI of the CDFW Restoration Manual, *Riparian Habitat Restoration,* contains examples of these techniques.

Reduction of instream sediment will improve fish habitat and fish survival by increasing fish embryo and alevin survival in spawning gravels, reducing injury to juvenile salmonids from high concentrations of suspended sediment, and minimizing the loss of, or reduction in size of, pools from excess sediment deposition. The proposed activities will reduce stream sedimentation from bank erosion by stabilizing stream banks with appropriate site-specific techniques including: boulder-streambank stabilization structures, log-streambank stabilization structures, tree revetment, native plant material revetment, willow wall revetment, willow siltation baffles, brush mattresses, checkdams, brush checkdams, water bars, and exclusionary fencing. Guidelines for stream bank stabilization techniques are described in Part VII of the CDFW Restoration Manual, *Project Implementation*. These types of projects usually require the use of heavy equipment (*e.g.*, self-propelled logging yarders, mechanical excavators, backhoes).

4. Removal of Small Dams (permanent and flashboard)

a. *Project Description*

The CDFW Restoration Manual does not cover the removal of small dams, however guidelines and minimization measures have been developed in this proposed action. Types of small dams are permanent, flash board, and seasonal dams with the characteristics listed below. Implementing these types of projects may require the use of heavy equipment (*e.g.*, self-propelled logging yarders, mechanical excavators, backhoes). Dams removed in part or in whole, by the use of explosives are not included in the proposed action.

Dams included in the Program are defined by the California Division of Dam Safety (California Water Code, 2010):

> Any artificial barrier which either (a) is less than 25 feet in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier to the maximum possible water storage elevation or (b) was designed to have an impounding capacity of less than 50 acre-feet.

In addition, this Program will only include dam removal that will form a channel at natural grade and shape upstream of the dam, naturally or with excavation, in order to minimize negative effects on downstream habitat. Dam removal projects will (1) have a relatively small volume of sediment available for release, that when released by storm flows, will have minimal effects on downstream habitat, or (2) are designed to remove sediment trapped by the dam down to the elevation of the target thalweg including design channel and floodplain dimensions. This can be accomplished by estimating the natural thalweg using an adequate longitudinal profile (CDFW Restoration Manual Part XII *Fish Passage Design and Implementation*) and designing a natural shaped channel that provides the same hydraulic conditions and habitat for listed fish that is provided by the natural channel and has the capacity to accommodate flows up to a 2-year flood.

b. *Minimization Measures*

- All construction will take place out of the wetted channel either by implementing the project from the bank and out of the channel or by constructing coffer dams, removing aquatic species located within the project reach, and dewatering the channel.
- No more than 250 linear feet (125 feet on each side of the channel) of riparian vegetation will be removed. All disturbed areas will be re-vegetated with native grasses, trees, or shrubs.
- All dewatering efforts associated with small dam removal will abide by the applicable minimization measures (Section D. *Sideboards, Minimization Measures, and Other Requirements*).

c. *Data Requirements and Analysis*

- A longitudinal profile of the stream channel thalweg for at least a distance equal to 20 channel widths upstream and downstream of the structure and long enough to establish the natural channel grade, whichever is farther, shall be used to determine the potential for channel degradation (as described in the CDFW Restoration Manual).

- A minimum of five cross-sections: one downstream of the structure, three roughly evenly spaced through the reservoir area upstream of the structure, and one upstream of the reservoir area outside of the influence of the structure to characterize the channel morphology and quantify the stored sediment.
- Sediment characterization within the reservoir and within a reference reach of a similar channel to determine the proportion of coarse sediment (>2mm) in the reservoir area and target sediment composition.
- A habitat typing survey (Restoration Manual Part III, Habitat Inventory Methods) that maps and quantifies all downstream spawning areas that may be affected by sediment released by removal of the water control structure.

Projects will be deemed ineligible for the program if: (1) sediments stored behind dam have a reasonable potential to contain environmental contaminants [dioxins, chlorinated pesticides, polychlorinated biphenyls (PCB's), or mercury] beyond the freshwater probable effect levels (PELs) summarized in the NOAA Screening Quick Reference Table guidelines or (2) the risk of significant loss or degradation of downstream spawning or rearing areas by sediment deposition is considered to be such that the project requires more detailed analysis. Sites shall be considered to have a reasonable potential to contain contaminants of concern if they are downstream of historical contamination sources such as lumber or paper mills, industrial sites, or intensive agricultural production going back several decades (*i.e.*, since chlorinated pesticides were legal to purchase and use). In these cases, preliminary sediment sampling is advisable.

5. Creation of Off-channel/Side Channel Habitat

a. *Project Description*

The creation of off-channel or side channel habitat is not included in the CDFW Restoration Manual, however, guidelines and minimization measures have been developed in this proposed action. Types of side channel or off-channel restoration projects that will be eligible for the Program are:

- Connection of abandoned side channel or pond habitats to restore fish access
- Connection of adjacent ponds, remnants from aggregate excavation
- Connection of oxbow lakes on floodplains that have been isolated from the meandering channel by river management schemes, or channel incision
- Creation of side channel or off-channel habitat with self-sustaining channels
- Improvement of hydrologic connection between floodplains and main channels

Projects that involve the installation of a flashboard dam, head gate or other mechanical structure are not part of the Program. Off channel ponds constructed under this Program will not be used as a point of water diversion. Use of logs or boulders as stationary water level control structures will be allowed.

Restoration projects in this category may include: removal or breaching of levees and dikes, channel and pond excavation, creating temporary access roads, constructing wood or rock tailwater control structures, and construction of LWD habitat features. Implementation of these types of projects may require the use of heavy equipment (*e.g.*, self-propelled logging yarders, mechanical excavators, backhoes).

Information regarding consideration of water supply (channel flow/overland flow/groundwater), water quality, and reliability; risk of channel change; as well as, channel and hydraulic grade will be provided in the project proposal for review by the Team. A good reference document for designing off channel habitat features can be found in "Section 5.1.2 Side Channel/Off Channel Habitat Restoration in the Washington Department of Fish and Wildlife 2004 Stream Habitat Restoration Guidelines" (Saldi-Caromile et al. 2004).

b. *Minimization Measures*

To reduce the effects of turbidity the same measures described in the CDFW Restoration Manual for Instream Habitat Improvement projects will be required including:

- Any equipment work within a stream channel shall be performed in isolation from the flowing stream. If there is any flow when the work is done, coffer dams shall be constructed upstream and downstream of the excavation site and divert all flow from upstream of the upstream dam to downstream of the downstream dam. The coffer dams may be constructed from many different materials and methods to meet the objective, for example clean river gravel or sand bags, and may be sealed with sheet plastic. Foreign materials such as sand bags and any sheet plastic shall be removed from the stream upon project completion. In some cases, clean river gravel may be left in the stream, but the coffer dams must be breached to return the stream flow to its natural channel.

- If it is necessary to divert flow around the work site, either by pump or by gravity flow, the suction end of the intake pipe shall be fitted with a fish screen that meets CDFW and NMFS (NMFS 1997) criteria to prevent entrainment or impingement of small fish. Any turbid water pumped from the work site shall be disposed of in an upland location where it will not drain directly into any stream channel, or treated via settling pond to filter suspended materials before flowing back into the stream.

If the Team determines that a proposed project requires extensive analysis, the project will undergo individual consultation.

6. Developing Alternative Stockwater Supply

a. *Project Description*

Many riparian fencing projects will require the development of off channel watering areas for livestock. These are often ponds that have been excavated and are filled either by rainwater, overland flow, surface diversions or groundwater (either through water table interception or pumping). The Program also covers water lines, watering troughs, and piping used to provide groundwater to livestock.

b. *Minimization Measures*

- Only projects with existing diversions compliant with water laws will be considered. In addition, storage reservoirs will not be greater than 10 acres in size. Flow measuring device installation and maintenance may be required for purposes of accurately

measuring and managing pumping rate or bypass conditions set forth in this document or in the water right or special use permit.
- All pump intakes will be screened in accordance with NMFS Southwest Region "Fish Screening Criteria for Salmonids" (NMFS 1997).
- Stockwater ponds and wells will be located at least 100 feet from the edge of the active channel and are not likely to cause stranding of juvenile salmonids during flood events.

7. Tailwater Collection Ponds

a. *Project Description*

Tailwater is created in flood irrigation operations as unabsorbed irrigation water flows back into the stream. Restoration projects to address tailwater input will construct tailwater capture systems to intercept tailwater before it enters streams. Water held in capture systems, such as a pond, can be reused for future irrigation purposes, therefore reducing the need for additional stream diversions.

b. *Minimization Measures*

- Tailwater collection ponds that do not incorporate return channels to the creek will be located at least 100 feet from the edge of the active channel and are not likely to cause stranding of juvenile salmonids during flood events.

8. Water Storage Tanks

a. Project Description

Water storage tanks could either be filled through rainwater catchment or by surface or groundwater flow. Under this programmatic, all water storage tank projects will be required to enter into a forbearance agreement for at least 10 years, which will provide temporal and quantitative assurances for pumping activities that result in less water withdrawal during summer low flow period. The low flow threshold, measured in cubic feet per second (cfs) season of diversion and season of storage, will be determined in collaboration with CDFW and NOAA RC on a site by site basis. Water storage capacity for the water diversion forbearance period must be of sufficient capacity to provide for all water needs during that time period. For example, if the no-pump period is 105 days (August to November), the diverters must have enough storage to cover any domestic, irrigation, or livestock needs during that time.

b. *Minimization Measures*

- All pump intakes will be properly screened in accordance with NMFS (1996, 1997) fish screen criteria.

Water conservation projects that include water storage tanks and a Forbearance Agreement for the purpose of storing winter and early spring water for summer and fall use, require registration of water use pursuant to California Water Code § 1228.3, and require consultation with CDFW. Diversions to fill storage facilities during the winter and spring months shall be made pursuant to a Small Domestic Use Appropriation filed with the State Water Resources Control Board.

9. Piping Ditches

a. *Project Description*

Piping projects consist of constructing a pipe to transport irrigation water instead of a ditch, thereby reducing evaporation and absorption. Water saved by these projects will remain in the stream for anadromous salmonid benefits. Applicants must demonstrate that they intend to dedicate water for instream beneficial use by filing a *Petition for Instream Flow Dedication* (California Water Code § 1707, 1991) and make progress towards instream dedication**.**

b. *Minimization Measures*

- Only water conservation piping projects that result in a decrease in the diversion rate with a permitted instream dedication of the water saved are included in the Program.
- Landowners will enter an agreement with Reclamation stating that they will maintain the pipe for at least 10 years.

10. Fish Screens

a. *Project Description*

This category includes the installation, operation, and maintenance of the types of fish screens described below, provided they meet the NMFS (1996, 1997) fish screening criteria. Installing a fish screen usually includes site excavation, forming and pouring a concrete foundation and walls, excavation and installation of a fish bypass pipe or channel, and installation of the fish screen structure. Heavy equipment is typically used for excavation of the screen site and bypass. If the fish screen is placed within or near flood prone areas, typically rock or other armoring is installed to protect the screen. The average area of the bed, channel, and bank disturbed by the installation of a bypass pipe or channel ranges from 40 to 100 square feet, based on past Scott and Shasta river screening projects. Fish screen types include:

- Self-cleaning screens, including flat plate self-cleaning screens, and other self-cleaning designs, including, but not limited to, rotary drum screens and cone screens, with a variety of cleaning mechanisms, consistent with NMFS fish screening criteria (NMFS 1996, 1997).
- Non-self-cleaning screens, including tubular, box, and other screen designs consistent with NMFS screening criteria (NMFS 1996, 1997).

b. *Minimization Measures*

- All flows will be diverted around work areas as described in the *Requirements for Fish Relocation and Dewatering Activities.*
- Fish removal may be required at project sites and BMPs will be implemented as described in the *Requirements for Fish Relocation and Dewatering Activities.*
- Riparian disturbance will be minimized as described in the *Measures to Minimize Loss or Disturbance of Riparian Vegetation.*

11. Headgates and Water Measuring Devices

a. *Project Description*

Measuring devices are typically installed with the head gate to allow water users to determine the volume of water diverted. Headgate installation projects must clearly demonstrate habitat restoration benefits.

b. *Minimization Measures*

- The application must include instream and ditch/pump hydraulic calculations showing there is sufficient head to divert maximum diversion flow and bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, and headgates.
- Measuring devices must be approved by DWR for watersheds with DWR water master service. Otherwise, measuring devices must conform to the *2001 Bureau of Reclamation Water Measurement Manual* (Reclamation 2001).
- Design drawings must show structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views along with important component details.
- All flows will be diverted around work areas as described in Section II B. *Requirements for Fish Relocation and Dewatering Activities.*
- Fish removal may be required at project sites and BMPs are described in Section II B. *Requirements for Fish Relocation and Dewatering Activities.*
- Riparian disturbance will be minimized as described in Section II E. *Measures to Minimize Loss or Disturbance of Riparian Vegetation.*

D. Sideboards, Minimization Measures, and other Requirements

A key component of the Program involves the use of sideboards that establish a minimum distance between instream projects and limit the number of instream projects annually within a watershed; relative to the size of the watershed. These sideboards also establish specific, measureable project metrics that assist with the analysis of effects. Additionally, the Reclamation has established additional requirements and minimization measures that must be implemented for projects included in the Program. The following are the sideboards, minimization measures, and other requirements proposed by Reclamation for proposed restoration projects:

1. Sideboards for all Water Conservation Projects

a. *Compliance with Water Rights*

All water conservation projects in the Program will require diverters to verify compliance with water rights — as conditioned by a small domestic use or livestock stockpond registration, appropriative water right, or a statement of riparian water use registered with the State Water Resources Control Board and reviewed for compliance with California Fish and Game Code (which may require a Lake or Streambed Alteration Agreement and possibly, a California Environmental Quality Act (CEQA) analysis) by Reclamation or the applicant.

b. Site-Specific Restrictions

Restrictions on water diversions from a stream or from hydrologically connected sources (such as springs or groundwater that would contribute to streamflow) are often site-specific. Many of the water conservation projects require change to diversion timing or rates, however, site-specific restrictions to those permits may make a project ineligible to the Program or subject to additional requirements. Diversion permits may have limits on or requirements for:

- Season of diversion
- Rates of diversion
- Possible time-of-day restrictions (avoiding daytime peak in forest evapotranspiration and water temperature, or coordination with other users)
- Fish screen requirements for direct diversions
- Requirements for water storage during high flow periods for use in low flow periods
- Flow or diversion monitoring and reporting.

c. Protection of Instream Flows

The following restrictions are intended to protect instream flows beneficial to fish rearing, spawning, and movement as well as providing habitat native amphibians and other aquatic species. Water conservation projects that involve diversions will need additional information to help determine the benefits to fish and if the proposed design is appropriate for the individual project site. The following information will be required:

- Proposed rate of diversion
- Season of diversion
- Diversion records (riparian and appropriative) both upstream and downstream of the project site
- Estimated water use and storage needs for proposed project
- Household/property water conservation plan (low flow shower heads, toilets, etc.)
- Estimated stream gradient and substrate
- Method of accurately measuring diversion rate

2. <u>Engineering Requirements</u>

More complex project types covered by the Program require a higher level of oversight (engineering review, etc.) and review by an engineer. These project types will include:

- Fish passage at stream crossings
- Permanent removal of flashboard dam abutments and sills.
- Small dam removal
- Creation and connection of off channel habitat features

Specific requirements associated with these more complex project types include the following:

- For road-stream crossings and small dam projects, if the stream at the project location was not passable to or was not utilized by all life stages of all listed salmonids in the

project area prior to the existence of the road crossing, the project shall pass the life stages and covered salmonid species that historically existed. Retrofitted culverts shall meet the fish passage criteria for the passage needs of the listed species and life stages historically passing through the site prior to the existence of the road crossing, according to CDFW stream crossing criteria (*CDFW Culvert Criteria for Fish Passage* (Appendix IX-A, CDFW Restoration Manual).
- All designs for dam removal, off channel habitat features, and fish passage projects will be reviewed by engineers, ensuring the requirements have been met prior to commencement of work. Off channel habitat projects that reduce the potential for stranding using water control structures will be encouraged, but uncertainties in future stream flows and drought conditions cannot be predicted and may result in fish stranding in certain flow conditions.

3. Prohibited Activities

Projects that include any of the following elements would not be authorized under the Program:

- Use of gabion baskets.
- Use of cylindrical riprap (aqualogs).
- Chemically-treated timbers used for any instream structures.
- Activity that substantially disrupts the movement of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the action area.
- Projects that would completely eliminate a riffle/pool complex (*note: there may be some instances where a riffle/pool complex is affected/modified by a restoration project [i.e. a culvert removal that affects an existing pool]. These types of projects would be allowed under the Program).*

4. Limits on Area of Disturbance for Individual Projects

a. *Stream Dewatering*

Maximum length of stream that can be dewatered is 1000 feet.

b. *Buffer Between Projects Implemented in the Same Year*

All projects implemented in the same year will maintain an 800 ft downstream buffer from any other sediment producing projects proposed for implementation that same year under the Program.

5. Limits on Removal of Vegetation

Removal of exotic, invasive riparian vegetation in a stream with high water temperatures must be done in a manner to avoid creation of additional temperature loading to fish-bearing streams. If a stream has a 7-day moving average daily maximum (7DMADM) temperature greater than 17.8 ºC in a coho salmon or steelhead stream, or greater than 18.5 ºC in a steelhead only stream, and vegetation management would reduce overstory shade canopy to the wetted channel, then the practice will not be allowed.

6. Protection Measures

The following protection measures, as they apply to a particular project, shall be incorporated into the project descriptions for individual projects authorized under the Program.

a. General Protection Measures

- Work shall not begin until (a) the Reclamation has notified the applicant to the Program that the requirements of the ESA have been satisfied and that the activity is authorized and (b) all other necessary permits and authorizations are finalized.
- The general construction season shall be from June 15 to November 1. Restoration, construction, fish relocation, and dewatering activities within any wetted or flowing stream channel shall only occur within this period. Revegetation outside of the active channel may continue beyond November 1, if necessary.
- Prior to construction, any contractor shall be provided with the specific protective measures to be followed during implementation of the project. In addition, a qualified biologist shall provide the construction crew with information on the listed species and State Fully Protected Species in the project area, the protection afforded the species by the ESA, and guidance on those specific protection measures that must be implemented as part of the project.
- All activities that are likely to result in negative aquatic effects, including temporary effects, shall proceed through a sequencing of effect reduction: avoidance, reduction in magnitude of effect, and compensation (mitigation). Mitigation may be proposed to compensate for negative effects to waters of the United States. Mitigation shall generally be in kind, with no net loss of waters of the United States on a per project basis. Mitigation work shall proceed in advance or concurrently with project construction.
- Poured concrete shall be excluded from the wetted channel for a period of 30 days after it is poured. During that time the poured concrete shall be kept moist, and runoff from the concrete shall not be allowed to enter a live stream. Commercial sealants may be applied to the poured concrete surface where difficulty in excluding water flow for a long period may occur. If sealant is used, water shall be excluded from the site until the sealant is dry and fully cured according to the manufacturers specifications.
- If the thalweg of the stream has been altered due to construction activities, efforts shall be undertaken to reestablish it to its original configuration[14].

b. Requirements for Fish Relocation and Dewatering Activities

(1) Guidelines for dewatering. Project activities funded or permitted under the Program may require fish relocation or dewatering activities. Dewatering may not be appropriate for some projects that will result in only minor input of sediment, such as placing logs with hand crews, or installing boulder clusters. Dewatering can result in the temporary loss of aquatic habitat, and the stranding, or displacement of fish and amphibian species. Increased turbidity may occur

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[14] Projects that may include activities, such the use of willow baffles, which may alter the thalweg are allowed

from disturbance of the channel bed. The following guidelines may minimize potential effects for projects that require dewatering of a stream:

- In those specific cases where it is deemed necessary to work in flowing water, the work area shall be isolated and all flowing water shall be temporarily diverted around the work site to maintain downstream flows during construction.
- Exclude fish from occupying the work area by blocking the stream channel above and below the work area with fine-meshed net or screens. Mesh will be no greater than 1/8 inch diameter. The bottom of a seine must be completely secured to the channel bed. Screens must be checked twice daily and cleaned of debris to permit free flow of water. Block nets shall be placed and maintained throughout the dewatering period at the upper and lower extent of the areas where fish will be removed. Block net mesh shall be sized to ensure salmonids upstream or downstream do not enter the areas proposed for dewatering between passes with the electrofisher or seine.
- Prior to dewatering, determine the best means to bypass flow through the work area to minimize disturbance to the channel and avoid direct mortality of fish and other aquatic vertebrates (as described more fully below under ***General conditions for all fish capture and relocation activities***.
- Coordinate project site dewatering with a qualified biologist to perform fish and amphibian relocation activities. The qualified biologist(s) must possess a valid state of California Scientific Collection Permit as issued by the CDFW and must be familiar with the life history and identification of listed salmonids and listed amphibians within the action area.
- Prior to dewatering a construction site, qualified individuals will capture and relocate fish and amphibians to avoid direct mortality and minimize adverse effects. This is especially important if listed species are present within the project site.
- Minimize the length of the dewatered stream channel and duration of dewatering, to the extent practicable.
- Any temporary dam or other artificial obstruction constructed shall only be built from materials such as sandbags or clean gravel which will cause little or no siltation. Visqueen shall be placed over sandbags used for construction of cofferdams construction to minimize water seepage into the construction areas. Visqueen shall be firmly anchored to the streambed to minimize water seepage. Coffer dams and stream diversion systems shall remain in place and fully functional throughout the construction period.
- When coffer dams with bypass pipes are installed, debris racks will be placed at the bypass pipe inlet. Bypass pipes will be monitored a minimum of two times per day, seven days a week. All accumulated debris shall be removed.
- Bypass pipes will be sized to accommodate, at a minimum, twice the summer baseflow.
- The work area may need to be periodically pumped dry of seepage. Place pumps in flat areas, well away from the stream channel. Secure pumps by tying off to a tree or stake in place to prevent movement by vibration. Refuel in an area well away from the stream channel and place fuel absorbent mats under pump while refueling. Pump intakes shall be covered with 1/8 inch mesh to prevent potential entrainment of fish or amphibians that failed to be removed. Check intake periodically for impingement of fish or amphibians.
- If pumping is necessary to dewater the work site, procedures for pumped water shall include requiring a temporary siltation basin for treatment of all water prior to entering any waterway and not allowing oil or other greasy substances originating from operations

to enter or be placed where they could enter a wetted channel. Projects will adhere to NMFS Southwest Region *Fish Screening Criteria for Salmonids* (NMFS 1997).
- Discharge sediment-laden water from construction area to an upland location or settling pond where it will not drain sediment-laden water back to the stream channel.
- When construction is complete, the flow diversion structure shall be removed as soon as possible in a manner that will allow flow to resume with the least disturbance to the substrate. Cofferdams will be removed so surface elevations of water impounded above the cofferdam will not be reduced at a rate greater than one inch per hour. This will minimize the probability of fish stranding as the area upstream becomes dewatered.

(2) General conditions for all fish capture and relocation activities:

- Fish relocation and dewatering activities shall only occur between June 15 and November 1 of each year.
- All seining, electrofishing, and relocation activities shall be performed by a qualified fisheries biologist. The qualified fisheries biologist shall capture and relocate listed salmonids prior to construction of the water diversion structures (*e.g.*, cofferdams). The qualified fisheries biologist shall note the number of salmonids observed in the affected area, the number and species of salmonids relocated, where they were relocated to, and the date and time of collection and relocation. The qualified fisheries biologist shall have a minimum of three years field experience in the identification and capture of salmonids, including juvenile salmonids, considered in this biological opinion. The qualified biologist will adhere to the following requirements for capture and transport of salmonids:
    - Determine the most efficient means for capturing fish (*i.e.*, seining, dip netting, trapping, electrofishing). Complex stream habitat generally requires the use of electrofishing equipment, whereas in outlet pools, fish may be concentrated by pumping-down the pool and then seining or dipnetting fish.
    - Notify NMFS one week prior to capture and relocation of salmonids to provide NMFS an opportunity to monitor.
    - Initial fish relocation efforts will be conducted several days prior to the start of construction. This provides the fisheries biologist an opportunity to return to the work area and perform additional electrofishing passes immediately prior to construction. In many instances, additional fish will be captured that eluded the previous day's efforts.
    - In streams with high water temperature, perform relocation activities during morning periods.
- Prior to capturing fish, determine the most appropriate release location(s). Consider the following when selecting release site(s):
    - Similar water temperature as capture location
    - Ample habitat for captured fish
    - Low likelihood of fish reentering work site or becoming impinged on exclusion net or screen.
    - Fish must be released in a nearby location within the same HUC 8 watershed
- Periodically measure air and water temperatures. Cease activities when measured water temperatures exceed 17.8 ºC. Temperatures will be measured at the head of riffle tail of pool interface.

(3) Electrofishing Guidelines. The following methods shall be used if fish are relocated via electrofishing:

- All electrofishing will be conducted according to NMFS *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS 2000).
- The backpack electrofisher shall be set as follows when capturing fish:

  Voltage setting on the electrofisher shall not exceed 300 volts.

	Initial	Maximum
A) Voltage:	100 Volts	300 Volts
B) Duration:	500 µs (microseconds)	5 ms (milliseconds)
C) Frequency:	30 Hertz	70 Hertz

- A minimum of three passes with the electrofisher shall be conducted to ensure maximum capture probability of salmonids within the area proposed for dewatering.
- No electrofishing shall occur if water conductivity is greater than 350 microSiemens per centimeter (µS/cm) or when instream water temperatures exceed 17.8 °C. Water temperatures shall be measured at the pool/riffle interface. Direct current (DC) shall be used.
- A minimum of one assistant shall aid the fisheries biologist by netting stunned fish and other aquatic vertebrates.

(4) Seining guidelines. The following methods, shall be used if fish are removed with seines.

- A minimum of three passes with the seine shall be utilized to ensure maximum capture probability of salmonids within the area.
- All captured fish shall be processed and released prior to each subsequent pass with the seine.
- The seine mesh shall be adequately sized to ensure fish are not gilled during capture and relocation activities.

(5) Guidelines for relocation of salmonids. The following methods shall be used during relocation activities associated with either method of capture (electrofishing or seining):

- Salmonid fish shall not be overcrowded into buckets; allowing approximately six cubic inches per young-of-the-year (0+) individual and more for larger fish.
- Every effort shall be made not to mix 0+ salmonids with larger salmonids, or other potential predators. Have at least two containers and segregate 0+ fish from larger age-classes. Place larger amphibians, such as Pacific giant salamanders, in container with larger fish.
- Salmonid predators, such as sculpins (*Cottus sp*.) and Pacific-giant salamanders (*Dicamptodon ensatus)* collected and relocated during electrofishing or seining activities shall be relocated so as to not concentrate them in one area. Particular emphasis shall be placed on avoiding relocation of sculpins and Pacific-giant salamanders into the steelhead and coho salmon relocation pools. To minimize predation on salmonids, these species

shall be distributed throughout the wetted portion of the stream so as not to concentrate them in one area.

- All captured salmonids shall be relocated, preferably upstream, of the proposed construction project and placed in suitable habitat. Captured fish shall be placed into a pool, preferably with a depth of greater than two feet with available instream cover.
- All captured salmonids will be processed and released prior to conducting a subsequent electrofishing or seining pass.
- All native captured fish will be allowed to recover from electrofishing before being returned to the stream.
- Minimize handling of salmonids. When handling is necessary, always wet hands or nets prior to touching fish. Handlers will not wear DEET based insect repellants.
- Temporarily hold fish in cool, shaded, aerated water in a container with a lid. Provide aeration with a battery-powered external bubbler. Protect fish from jostling and noise and do not remove fish from this container until time of release.
- Place a thermometer in holding containers and, if necessary, periodically conduct partial water changes to maintain a stable water temperature. If water temperature reaches or exceeds 18 °C. , fish shall be released and rescue operations ceased.
- In areas where aquatic vertebrates are abundant, periodically cease capture, and release at predetermined locations.
- Visually identify species and estimate year-classes of fishes at time of release. Record the number of fish captured. Avoid anesthetizing or measuring fish.
- If more than three percent of the steelhead, Chinook salmon, or coho salmon captured are killed or injured, the project lead shall contact NMFS PRD and CDFW. The purpose of the contact is to allow the agencies a courtesy review of activities resulting in take and to determine if additional protective measures are required. All steelhead, Chinook salmon, and coho salmon mortalities must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NMFS.

c. Measures to Minimize Disturbance from Instream Construction

Measures to minimize disturbance associated with instream habitat restoration construction activities are presented below.

- If the stream channel is seasonally dry between June 15 and November 1, construction will only occur during this dry period.
- Debris, soil, silt, excessive bark, rubbish, creosote-treated wood, raw cement/concrete or washings thereof, asphalt, paint or other coating material, oil or other petroleum products, or any other substances which could be hazardous to aquatic life, resulting from project related activities, shall be prevented from contaminating the soil or entering the waters of the United States. Any of these materials, placed within or where they may enter a stream or lake, by the applicant or any party working under contract, or with permission of the applicant, shall be removed immediately. During project activities, all trash that may attract potential predators of salmonids will be properly contained, removed from the work site, and disposed of daily.

- Where feasible, the construction shall occur from the bank, or on a temporary pad underlain with filter fabric.
- Use of heavy equipment shall be avoided in a channel bottom with rocky or cobbled substrate. If access to the work site requires crossing a rocky or cobbled substrate, a rubber tire loader/backhoe is the preferred vehicle. Only after this option has been determined infeasible will the use of tracked vehicles be considered. The amount of time this equipment is stationed, working, or traveling within the creek bed shall be minimized. When heavy equipment is used, woody debris and vegetation on banks and in the channel shall not be disturbed if outside of the project's scope.
- All mechanized equipment working in the stream channel or within 25 feet of a wetted channel shall have a double containment system for diesel and oil fluids. Hydraulic fluids in mechanical equipment working within the stream channel shall not contain organophosphate esters. Vegetable based hydraulic fluids are preferred.
- The use or storage of petroleum-powered equipment shall be accomplished in a manner to prevent the potential release of petroleum materials into waters of the state (Fish and Game Code 5650).
- Areas for fuel storage, refueling, and servicing of construction equipment must be located in an upland location.
- Prior to use, clean all equipment to remove external oil, grease, dirt, or mud. Wash sites must be located in upland locations so wash water does not flow into a stream channel or adjacent wetlands.
- All construction equipment must be in good working condition, showing no signs of fuel or oil leaks. Prior to construction, all mechanical equipment shall be thoroughly inspected and evaluated for the potential of fluid leakage. All mechanical equipment shall be inspected on a daily basis to ensure there are no motor oil, transmission fluid, hydraulic fluid, or coolant leaks. All leaks shall be repaired in the equipment staging area or other suitable location prior to resumption of construction activity.
- Oil absorbent and spill containment materials shall be located on site when mechanical equipment is in operation with 100 feet of the proposed watercourse crossings. If a spill occurs, no additional work shall commence in-channel until (1) the mechanical equipment is inspected by the contractor, and the leak has been repaired, (2) the spill has been contained, and (3) CDFW and NOAA RC are contacted and have evaluated the impacts of the spill.

d. Measures to Minimize Degradation of Water Quality

Construction or maintenance activities for projects covered under the Program may result in temporary increases in turbidity levels in the stream. The following measures will be implemented to reduce the potential for adverse effects to water quality during and post-construction:

(1) General erosion control during construction:

- When appropriate, isolate the construction area from flowing water until project materials are installed and erosion protection is in place.
- Effective erosion control measures shall be in place at all times during construction. Do not start construction until all temporary control devices (*e.g.,* straw bales with sterile,

weed free straw, silt fences*)* are in place downslope or downstream of project site within the riparian area. The devices shall be properly installed at all locations where the likelihood of sediment input exists. These devices shall be in place during and after construction activities for the purposes of minimizing fine sediment and sediment/water slurry input to flowing water and detaining sediment-laden water on site. If continued erosion is likely to occur after construction is complete, then appropriate erosion prevention measures shall be implemented and maintained until erosion has subsided. Erosion control devices such as coir rolls or erosion control blankets will not contain plastic netting of a mesh size that would entrain reptiles (esp. snakes) and amphibians.

- Sediment shall be removed from sediment controls once it has reached one-third of the exposed height of the control. Whenever straw bales are used, they shall be sterile and weed free, staked and dug into the ground 12 cm. Catch basins shall be maintained so that no more than 15 cm of sediment depth accumulates within traps or sumps.
- Sediment-laden water created by construction activity shall be filtered before it leaves the settling pond or enters the stream network or an aquatic resource area.
- The contractor/applicant to the Program is required to inspect, maintain or repair all erosion control devices prior to and after any storm event, at 24 hour intervals during extended storm events, and a minimum of every two weeks until all erosion control measures have been completed.

(2) Guidelines for temporary stockpiling:

- Minimize temporary stockpiling of material. Stockpile excavated material in areas where it cannot enter the stream channel. Prior to start of construction, determine if such sites are available at or near the project location. If nearby sites are unavailable, determine location where material will be deposited. Establish locations to deposit spoils well away from watercourses with the potential to delivery sediment into streams supporting, or historically supporting populations of listed salmonids. Spoils shall be contoured to disperse runoff and stabilized with mulch and (native) vegetation. Use devices such as plastic sheeting held down with rocks or sandbags over stockpiles, silt fences, or berms of hay bales, to minimize movement of exposed or stockpiled soils.
- If feasible, conserve topsoil for reuse at project location or use in other areas. End haul spoils away from watercourses as soon as possible to minimize potential sediment delivery.

(3) Minimizing potential for scour:

- When needed, utilize instream grade control structures to control channel scour, sediment routing, and headwall cutting.
- For relief culverts or structures, if a pipe or structure that empties into a stream is installed, an energy dissipater shall be installed to reduce bed and bank scour. This does not apply to culverts in fish bearing streams.
- The toe of rock slope protection used for streambank stabilization shall be placed below the bed scour depth to ensure stability.

(4) Post construction erosion control:

- Immediately after project completion and before close of seasonal work window, stabilize all exposed soil with erosion control measures such as mulch, seeding, and/or placement of erosion control blankets. Remove all artificial erosion control devices after the project area has fully stabilized. All exposed soil present in and around the project site shall be stabilized after construction. Erosion control devices such as coir rolls or erosion control blankets will not contain plastic netting of a mesh size that would entrain reptiles (esp. snakes) and amphibians.
- All bare and/or disturbed slopes (> 100 square ft of bare mineral soil) will be treated with erosion control measures such as hay bales, netting, fiber rolls, and hydroseed as permanent erosion control measures.
- Where straw, mulch, or slash is used as erosion control on bare mineral soil, the minimum coverage shall be 95 percent with a minimum depth of two inches.
- When seeding is used as an erosion control measure, only seeds from native plant species will be used. Sterile (without seeds), weed-free straw, free of exotic weeds, is required when hay or hay bales are used as erosional control measures.

e. Measures to Minimize Loss or Disturbance of Riparian Vegetation

Measures to minimize loss or disturbance to riparian vegetation are described below. The revegetation and success criteria that will be adhered to for projects implemented under this Program that result in disturbance to riparian vegetation are also described below.

(1) Minimizing disturbance:

- Retain as many trees and brush as feasible, emphasizing shade-producing and bank-stabilizing trees and brush.
- Prior to construction, determine locations and equipment access points that minimize riparian disturbance. Avoid entering unstable areas. Use project designs and access points that minimize riparian disturbance without affecting less stable areas, which may increase the risk of channel instability.
- Minimize soil compaction by using equipment with a greater reach or that exerts less pressure per square inch on the ground than other equipment, resulting in less overall area disturbed or less compaction of disturbed areas.
- If riparian vegetation is to be removed with chainsaws, consider using saws that operate with vegetable-based bar oil.

(2) Revegetation and success criteria:

- Any stream bank area left barren of vegetation as a result of the implementation or maintenance of the practices shall be restored to a natural state by seeding, planting, or other means with native trees, shrubs, or grasses prior to November 15 of the project year. Barren areas shall typically be planted with a combination of willow stakes, native shrubs and trees and/or erosion control grass mixes.
- Native plant species shall be used for revegetation of disturbed and compacted areas. The species used shall be specific to the project vicinity or the region of the state where

the project is located, and comprise a diverse community structure (plantings shall include both woody and herbaceous species).

- For projects where re-vegetation is implemented to compensate for riparian vegetation impacted by project construction, a re-vegetation monitoring report will be required after 5 years to document success. Success is defined as 70 percent survival of plantings or 70 percent ground cover for broadcast planting of seed after a period of 3 years. If revegation efforts will be passive (*i.e.*, natural regeneration), success will be defined as total cover of woody and herbaceous material equal to or greater than pre-project conditions. If at the end of five years, the vegetation has not successfully been re-established, the project applicant to the Program will be responsible for replacement planting, additional watering, weeding, invasive exotic eradication, or any other practice, to achieve the revegetation requirements. If success is not achieved within the first 5 years, the project applicant will need to prepare a follow-up report in an additional 5 years. This requirement will proceed in 5 year increments until success is achieved.
- All plastic exclusion netting placed around plantings will be removed after 3 years.

f. Measures to Minimize Impacts to Roads in Project Area

When defining the sideboard which restricts the number of projects per HUC 10 (Table 1), road decommissioning projects are considered to be one project; however, intensity of the project is buffered by the sideboards related to road-stream crossing removals, a sediment-producing activity.

Stream crossing activities within the project will be limited in accordance to the sideboard which limits distance to minimize cumulating sediment effects. Any stream crossing removals in a fish bearing stream must be 800 ft apart and crossings in a non-fish-bearing stream must be 500 ft apart.

E. Monitoring and Reporting Requirements

1. Pre-Project Monitoring and Submittal Requirements

The following information will be collected by the Program applicants with assistance from qualified biologists. Program applicants will submit the following information either to the Reclamation for project tracking and data reporting requirements. Program applicants will be responsible for obtaining any other necessary permits or authorizations from appropriate agencies before the start of project including, but not limited to a State Water Quality 401 Certification and local County permits. Any modification of the streambed, bank or channel requires notification to CDFW under the Lake or Streambed Alteration program. For all projects that do not meet the requirement of standard exemptions, project review under CEQA is likely to be necessary.

- Pre-project photo monitoring data (per CDFW's guidelines).
- Project Description:
  - Project problem statement,
  - Project goals and objectives, etc.
  - Watershed context.

  - Description of the type of project and restoration techniques utilized (culvert replacement, instream habitat improvements, etc.).
  - Project dimensions.
  - Description of Construction Activities Anticipated (types of equipment, timing, staging areas or access roads required).
  - If dewatering of the work site will be necessary, description of temporary dewatering methods including qualified individual who will be onsite to transport protected salmonids.
  - Construction start- and end-dates.
  - Estimated number of creek crossings and type of vehicle.
  - Materials to be used.
  - When vegetation will be affected as a result of the project, (including removal and replacement), provide a visual assessment of dominant native shrubs and trees, approximate species diversity, and approximate acreage.
  - Description of existing site conditions and explanation of how proposed activities improve or maintain these conditions for steelhead or coho move within the natural variability needed to support these species.
  - Description of key habitat elements (i.e., temperature; type: pool, riffle, flatwater; estimate of instream shelter and shelter components; water depth; dominant substrate type, etc.) for coho and steelhead in project area.
- Description of applicable minimization and avoidance measures incorporated into the individual project.
  - Description of any proposed deviations from that authorized in the BA will be clearly described. It is likely that any proposed deviations from the activities described in the *Proposed Action* subsection (above) or the required protection measures described (above), will result in the project not being covered under this Program and would require individual consultation.
  - Individual project applicants will be required to submit a proposed monitoring plan for the project describing how they will ensure compliance with the applicable monitoring requirements described in this Program description (revegetation, etc.), including the source of funding for implementation of the monitoring plan.
  - For projects that may result in incidental take of coho salmon; (*i.e.* that will require dewatering and fish relocation activities in a stream historically known to support coho), the applicant will also need to comply with the requirements of the California Endangered Species Act (CESA). CESA requires that impacts be minimized and fully mitigated and that funding for implementation is assured. Thus, for projects that have grant funding for implementation, the funding assurance shall be the grant/agreement itself, showing monies earmarked for implementation of necessary protection measures during implementation and follow-up monitoring, or another mechanism approved by NMFS and CDFW in writing. For projects that have no such grant funding, the applicant shall be required to provide security in the form of an Irrevocable Letter of Credit issued by a bank or other financial institution giving CDFW access to an account set up with the security deposit in an amount approved in writing by NMFS and CDFW. The funding security will be held until the required measures have been successfully implemented.

2. Post Construction Monitoring and Reporting Requirements

Implementation monitoring will be conducted for all projects implemented under the proposed Program. Following construction, individual applicants will submit a post-construction, implementation report to the Reclamation. The implementation report will also be sent to CDFW. Submittal requirements will include project as-built plans describing post implementation conditions and photo documentation of project implementation taken before, during, and after construction utilizing CDFW photo monitoring protocols. For fish relocation activities, the report will include: all fisheries data collected by a qualified fisheries biologist which shall include the number of listed salmonids killed or injured during the proposed action, the number and size (in millimeters) of listed salmonids captured and removed and any effects of the proposed action on listed salmonids not previously considered.

a. *Monitoring Requirements for Off-channel/Side Channel Habitat Features*

All off channel/side channel habitat projects included in the Program will require an additional level of physical and biological monitoring. In addition to the information collected during the pre-project monitoring and submittal requirements (above), the following information will also be collected by the Program applicants. Program applicants will submit the following information to Reclamation to help further understand these project types:

- Pre and post project photo monitoring data (per CDFW's guidelines)
- Project Description:
    - Project problem statement
    - Project goals and objectives, etc.
    - Watershed context
    - Description of the type of off channel feature and restoration techniques utilized
    - Project dimensions
    - Description of outlet control feature (if present)
    - If dewatering of the work site will be necessary, description of temporary dewatering methods including qualified individual who will be onsite to transport protected salmonids
    - Construction start and end dates
    - Materials to be used
    - When vegetation will be affected as a result of the project, (including removal and replacement), provide a visual assessment of dominant native shrubs and trees, approximate species diversity, and approximate acreage
    - Description of existing site conditions and explanation of how proposed activities improve or maintain these conditions for steelhead or coho salmon move within the natural variability needed to support these species
    - Description of key habitat elements (*i.e.*, temperature; habitat type: pool, riffle, flatwater; estimate of instream shelter and shelter components; water depth; dominant substrate type, etc.) for coho salmon and steelhead in project area
    - Pre and post (after winter flow event) information on the elevation of the inlet and outlet structure relative to the 2-year flood
    - A description of if and when the off channel feature became disconnected from the main channel and at what flow level (cfs). This will require checking the project site daily when the off channel feature is becoming disconnected from the main channel

  - A description of any stranded fish observed. If there are salmonids stranded, the applicant will contact NMFS PRD immediately to determine if a fish rescue action is necessary. CDFW will also be contacted with fish rescue information and/or mortalities by species.

3. Annual Report

Annually, Reclamation or its designee will prepare a report summarizing results of projects implemented under the Program during the most recent construction season and results of post-construction implementation and effectiveness monitoring for that year and previous years. The annual report shall include a summary of the specific type and location of each project. The report shall include the following project-specific information:

- A summary detailing fish relocation activities, including the number and species of fish relocated and the number and species injured or killed.
- A map indicating the location of each project
- The number and type of instream structures implemented within the stream channel.
- The size (acres, length, and depth) of off channel habitat features enhanced or created.
- The length of streambank (feet) stabilized or planted with riparian species.
- The number of culverts replaced or repaired, including the number of miles of restored access to unoccupied salmonid habitat.
- The size on number of dams removed, including the number of miles of restored access to unoccupied salmonid habitat.
- The distance (feet) of aquatic habitat disturbed at each project site.

References

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National Marine Fisheries Service . 1996. Juvenile Fish Screening Criteria for Pump Intakes. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Southwest Region.

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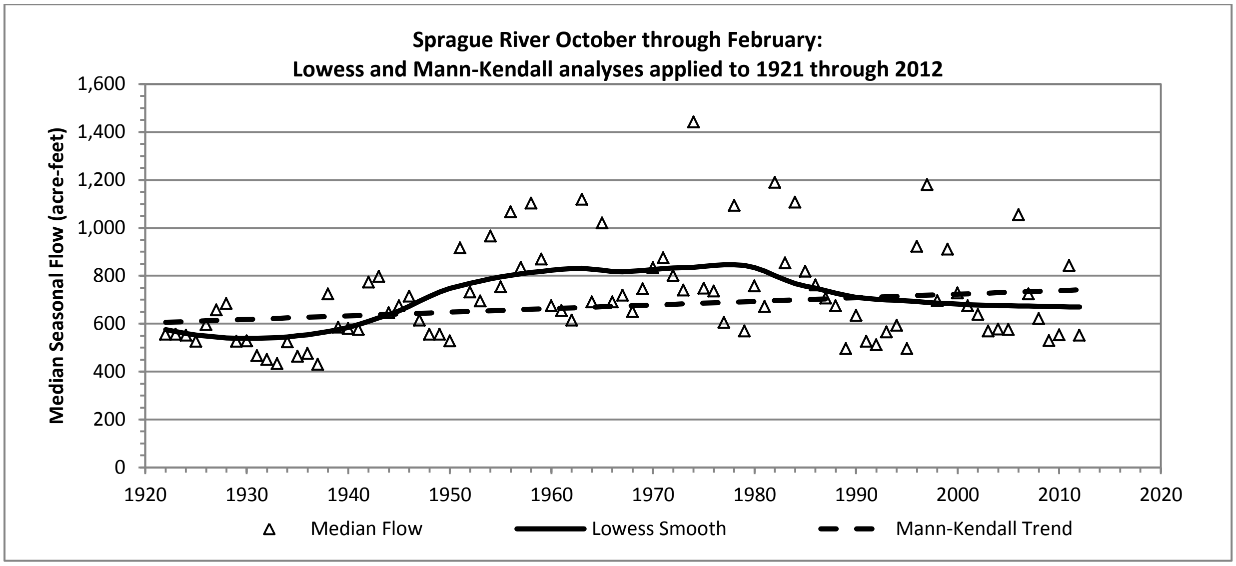
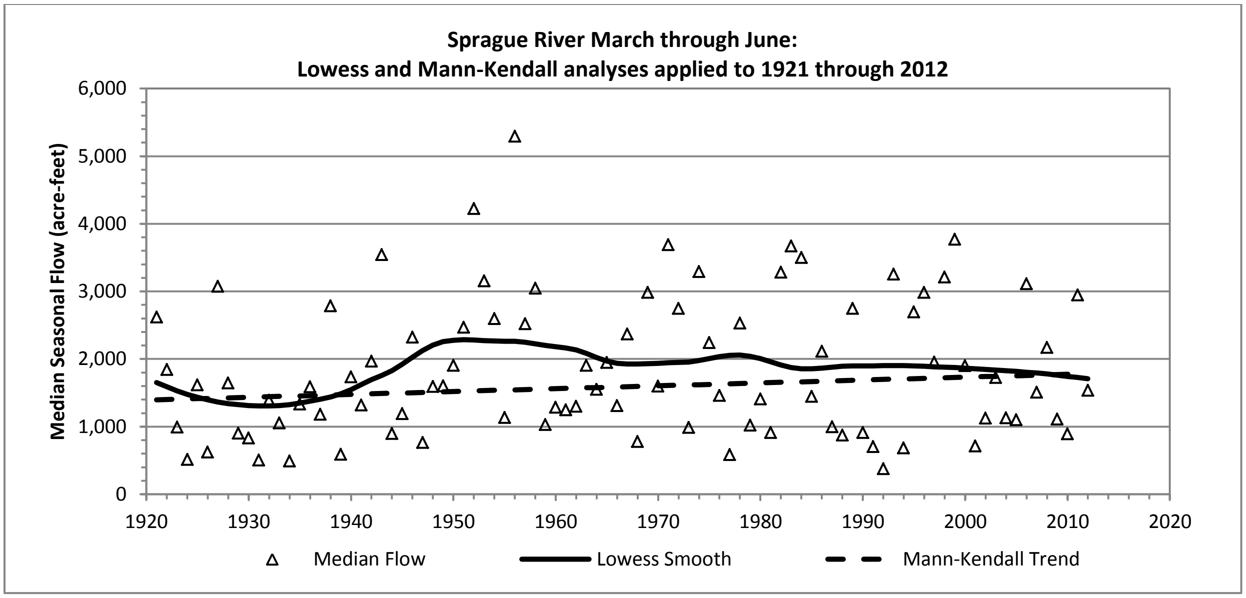
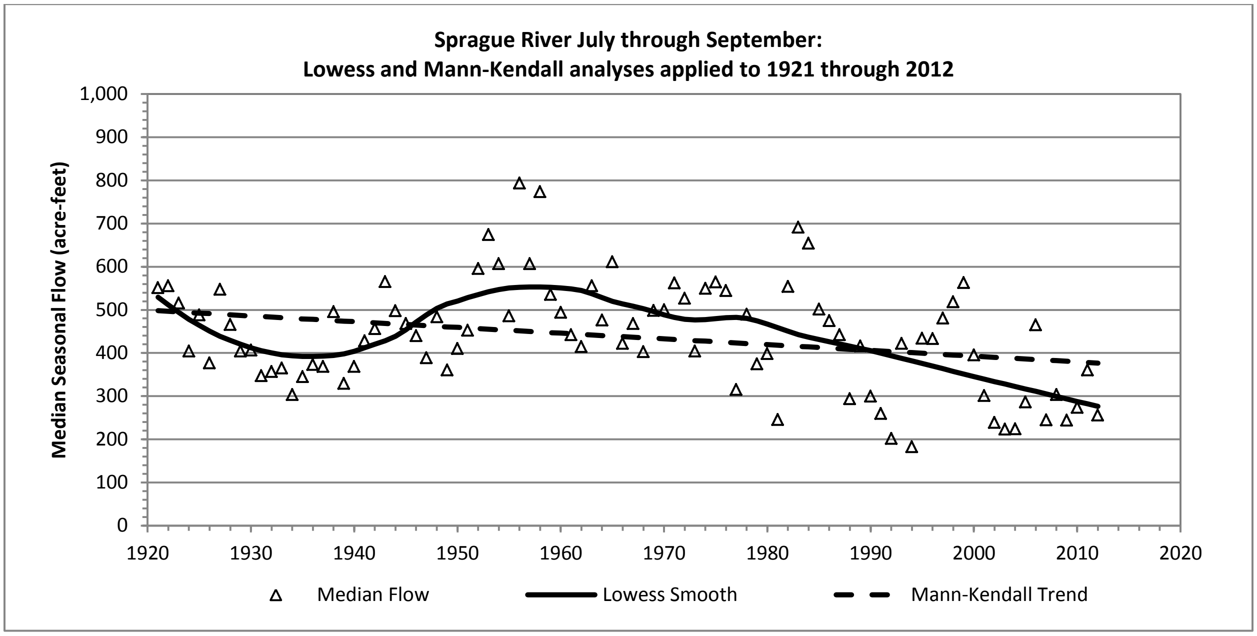
National Marine Fisheries Service. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

16.4 Appendix D: Trend Analyses



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1,000
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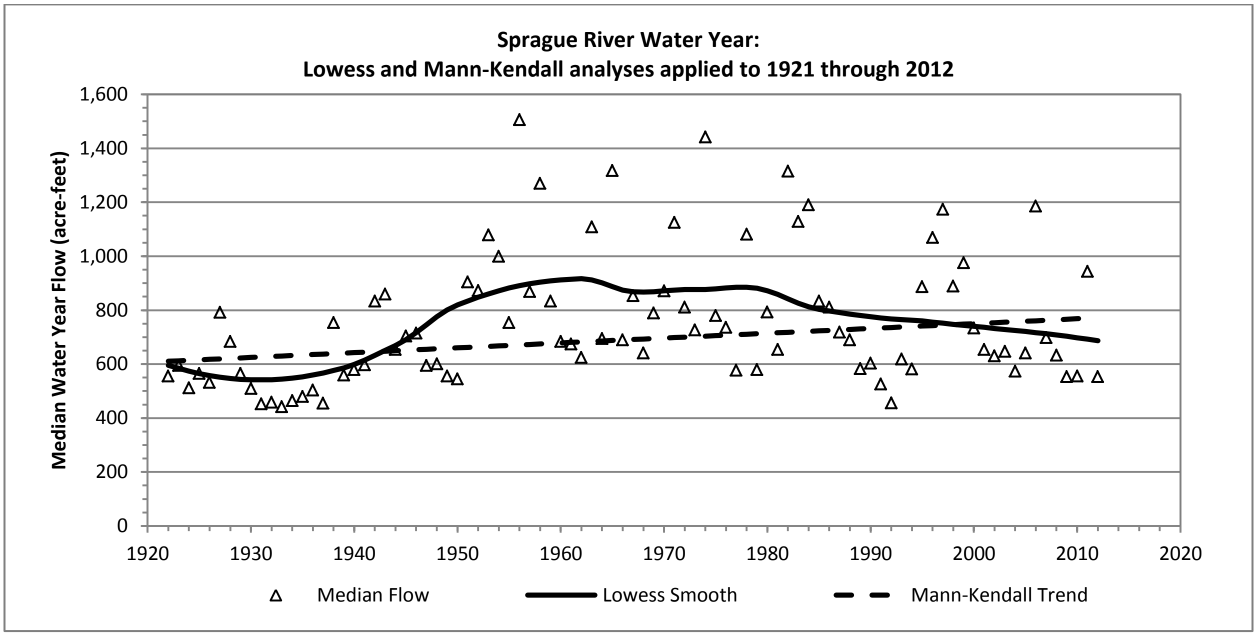
Mann-Kendall Trend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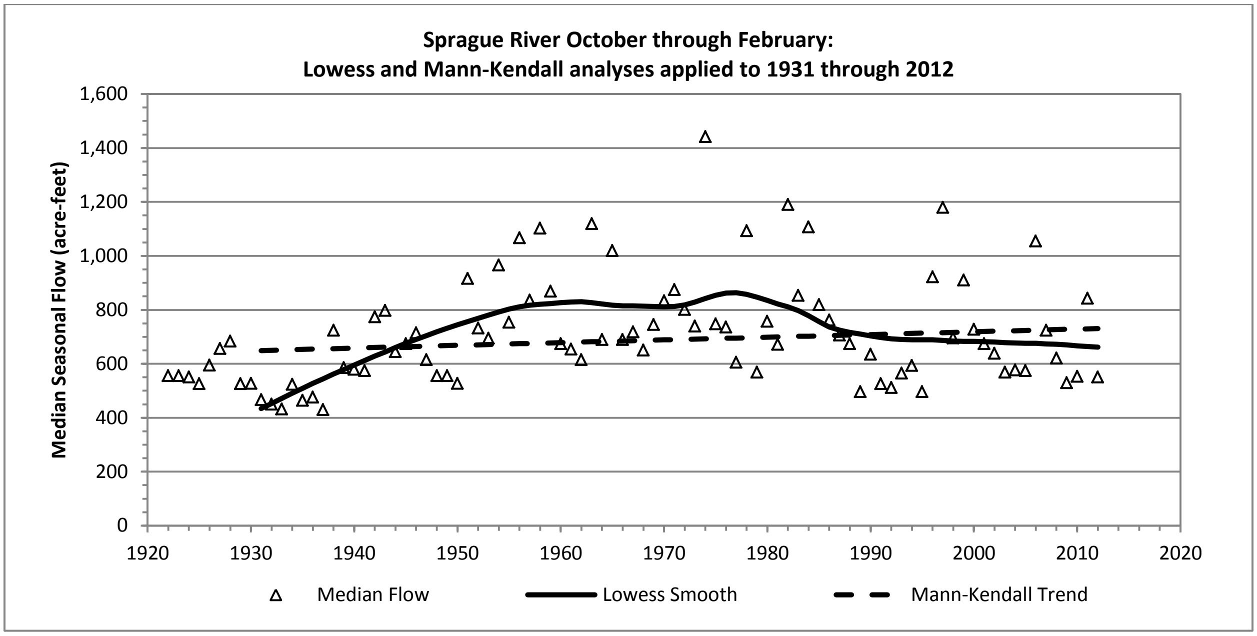
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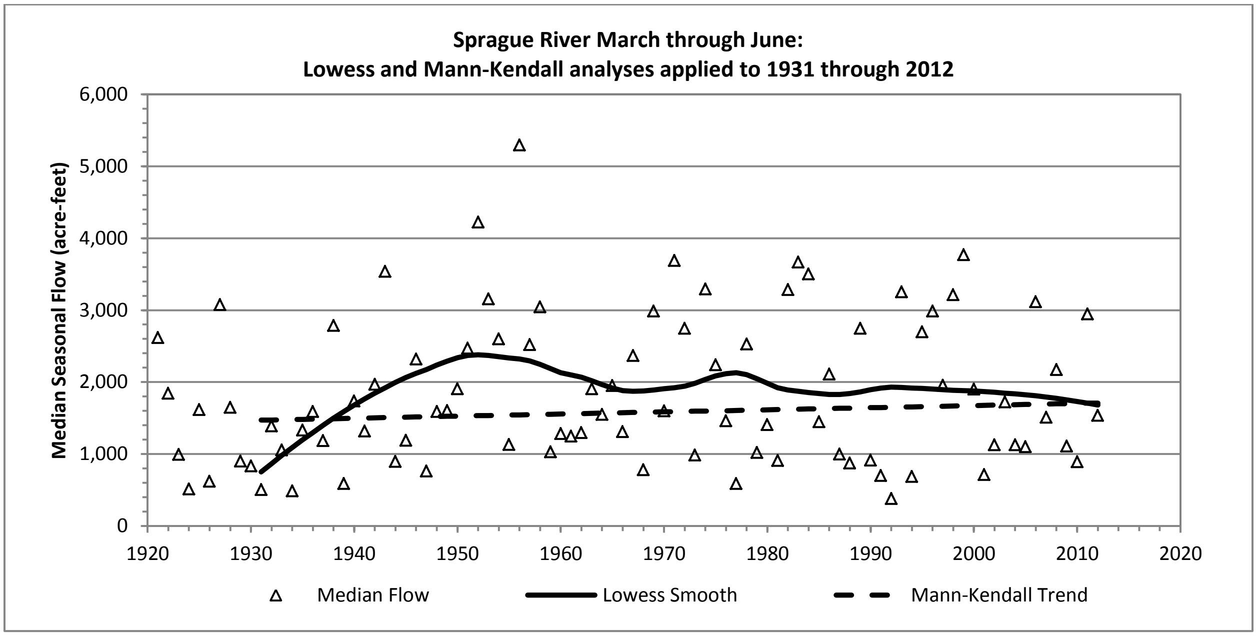
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Median Flow
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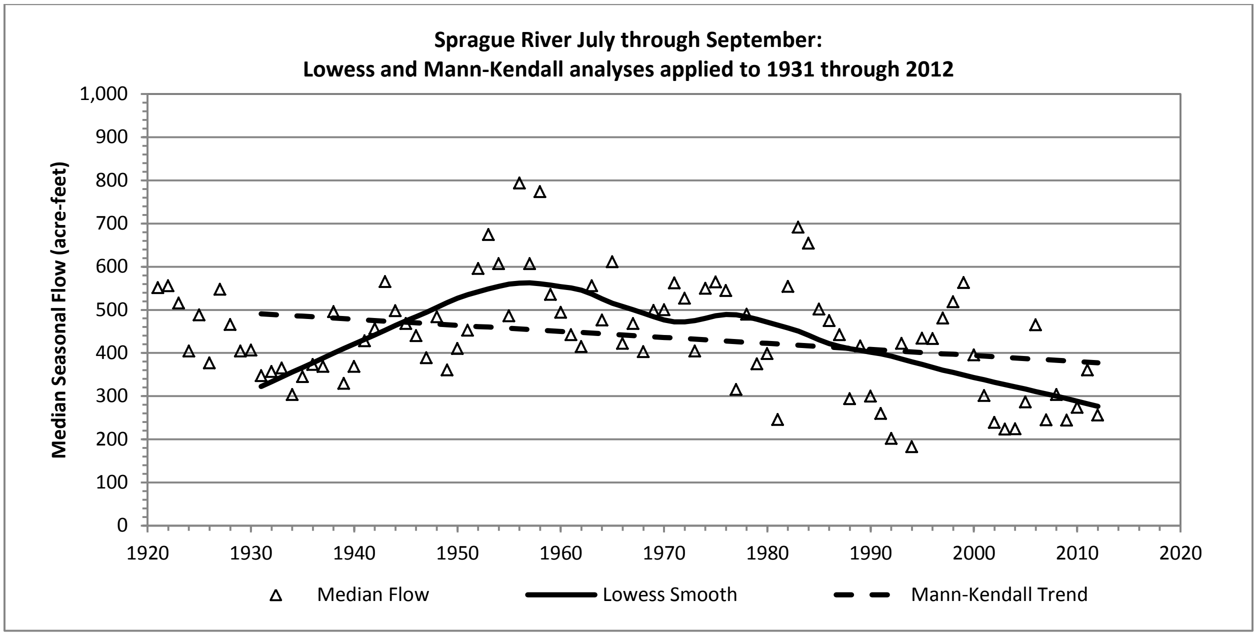
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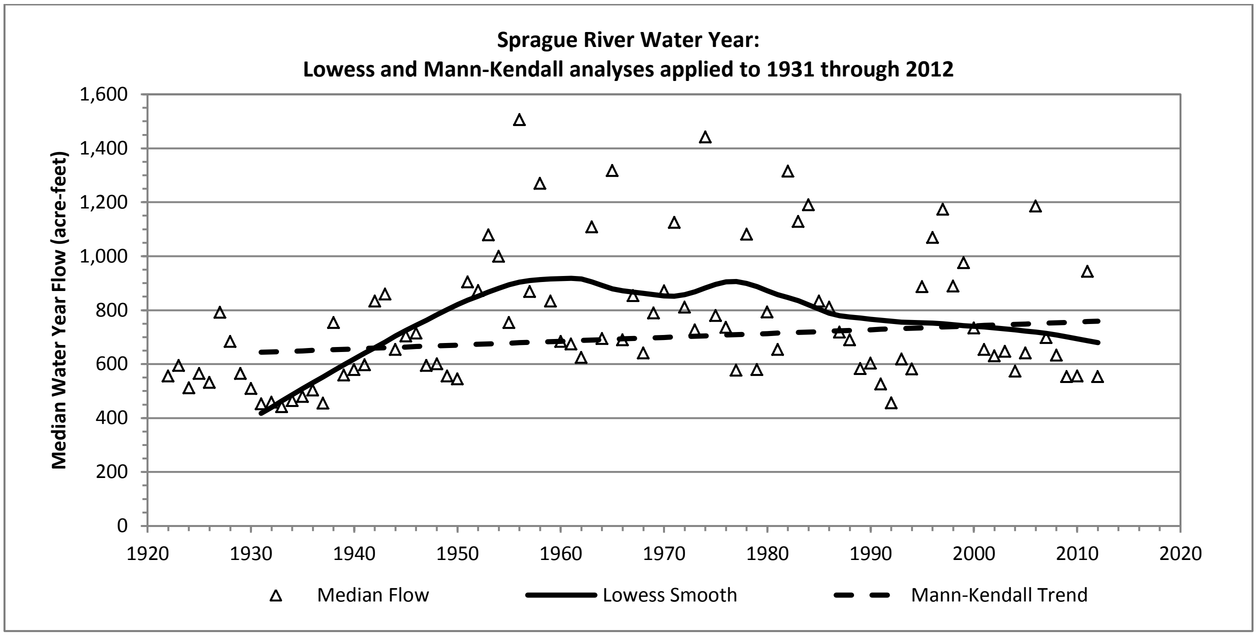
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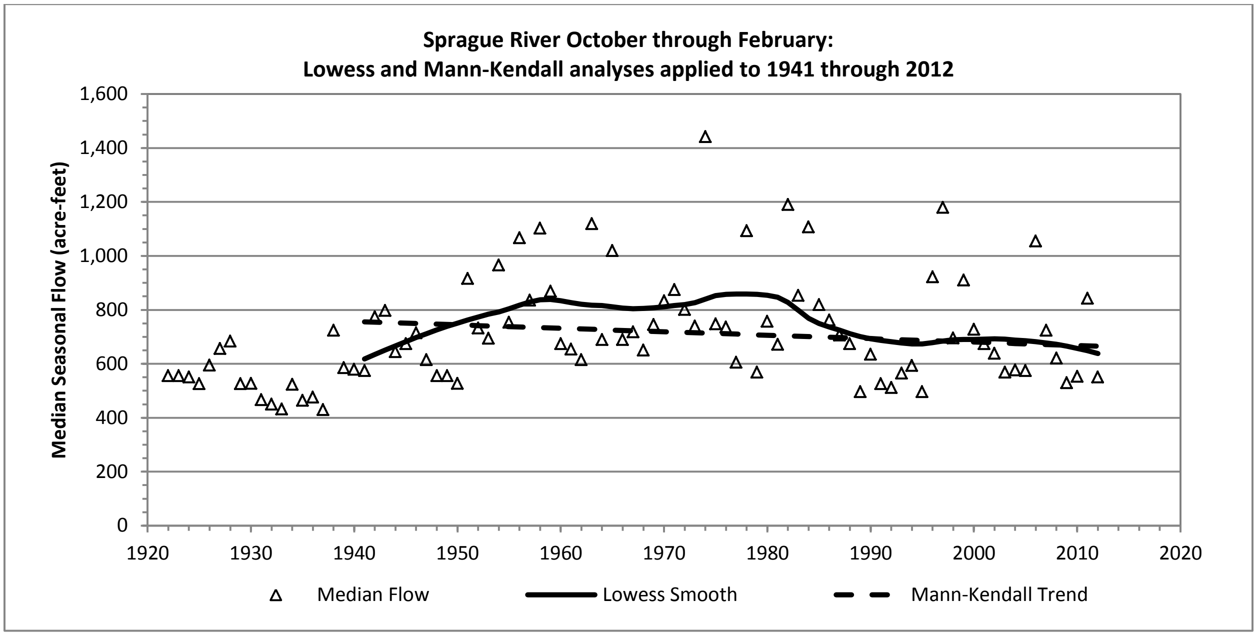
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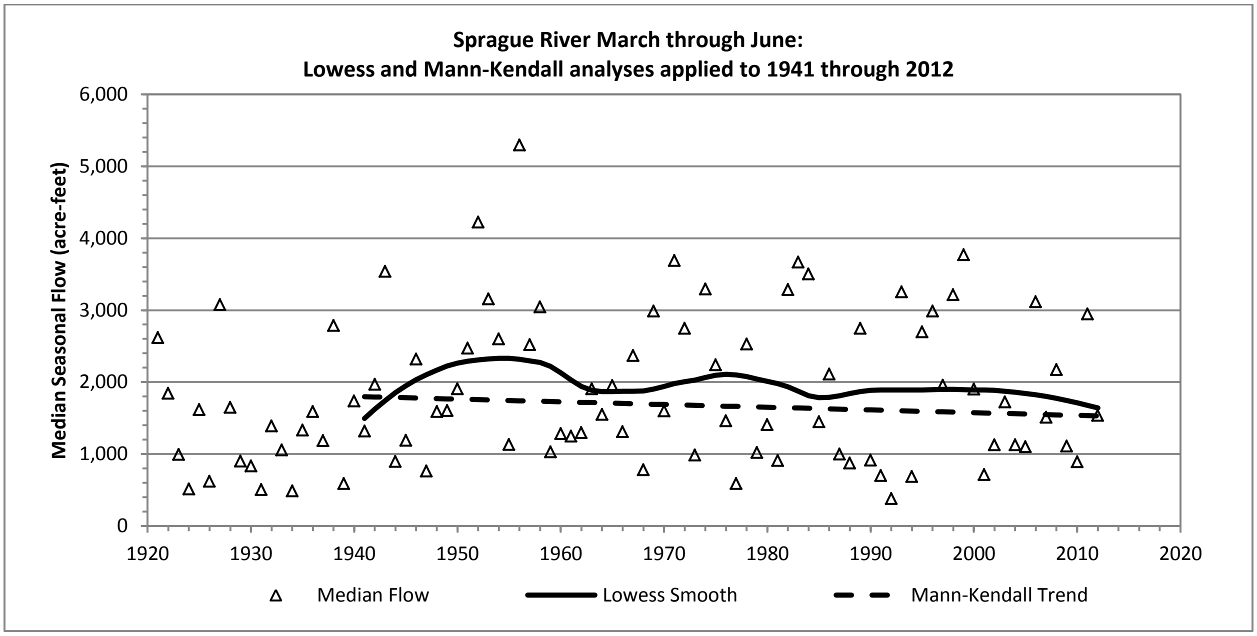
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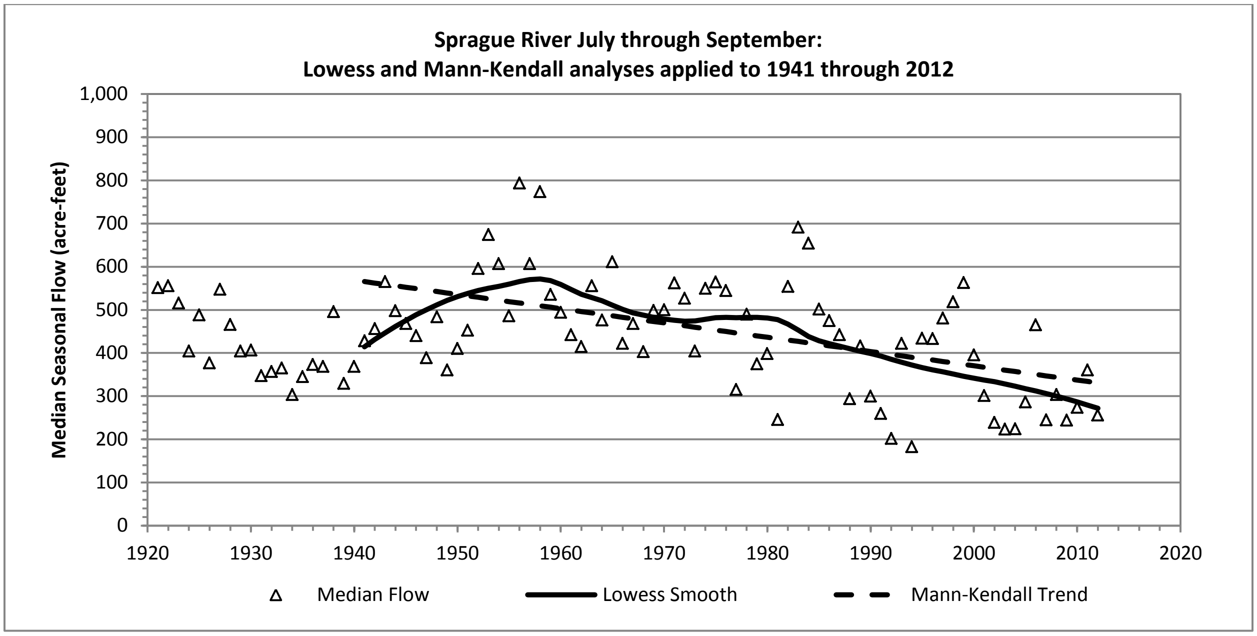
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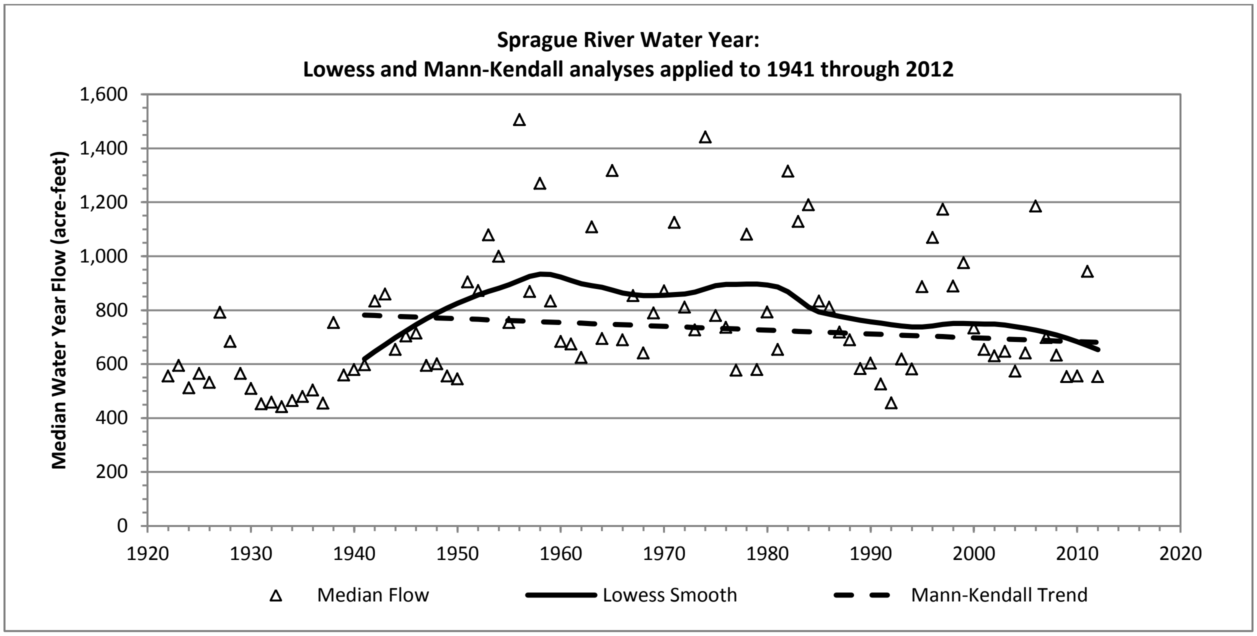
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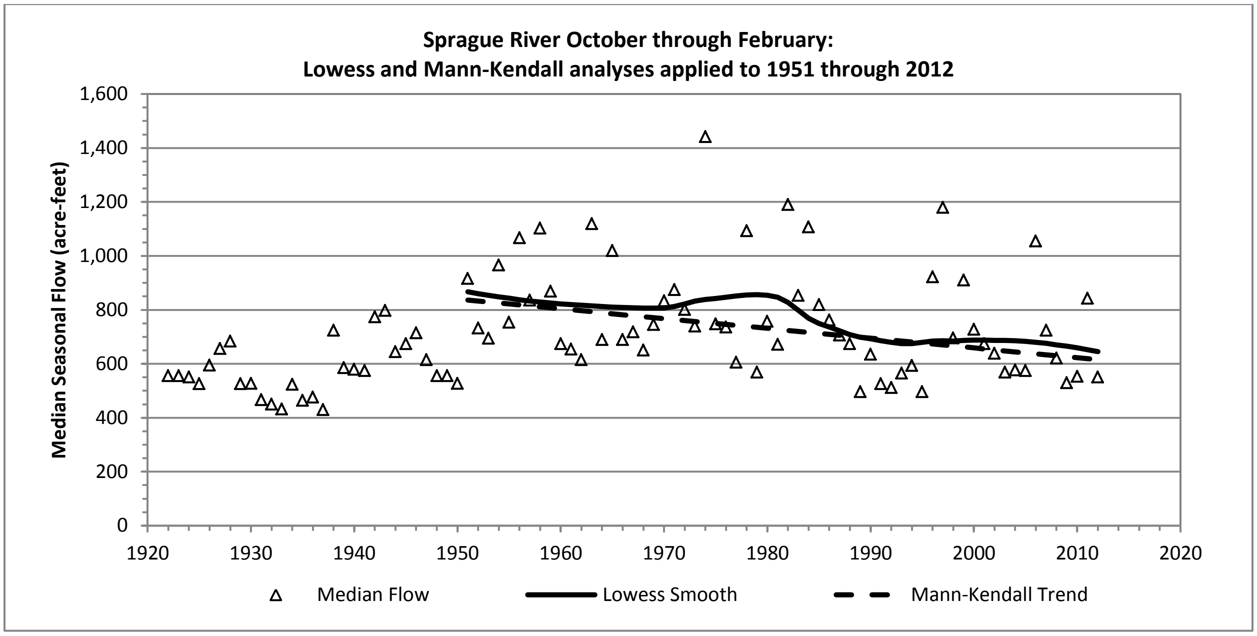
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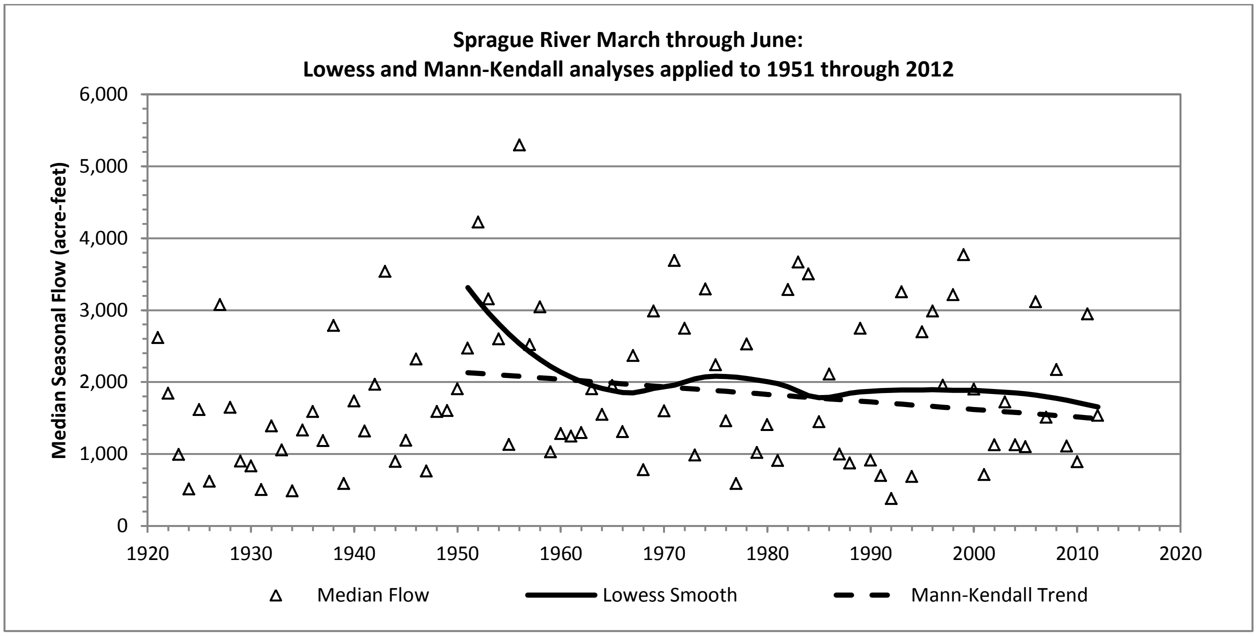
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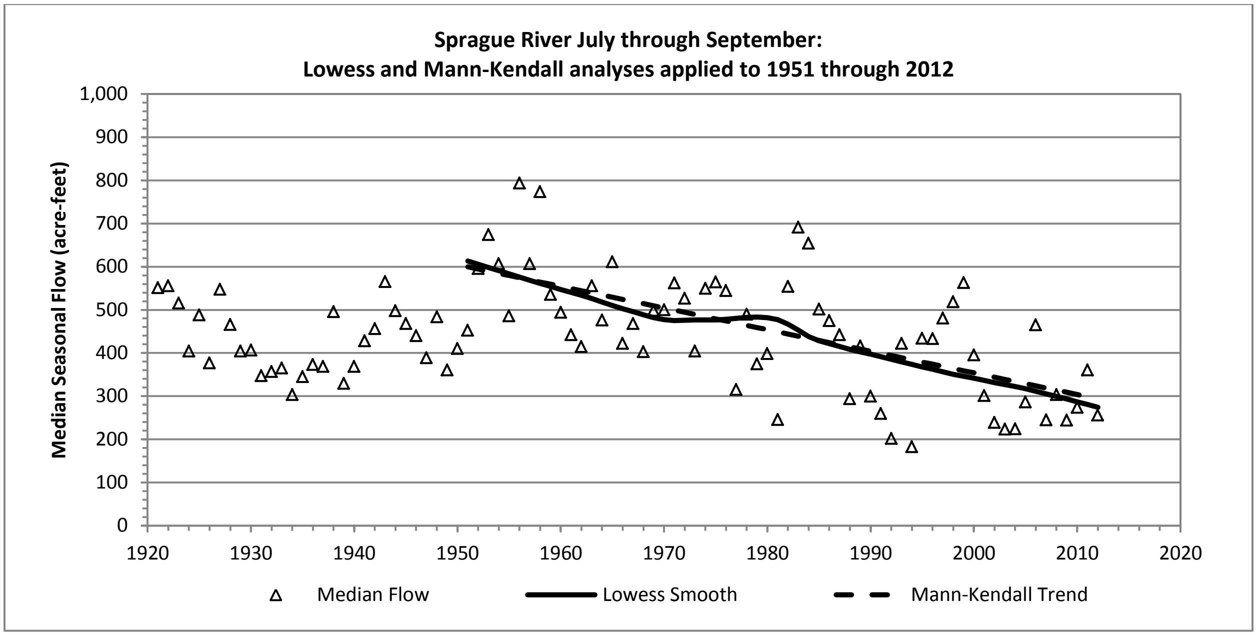

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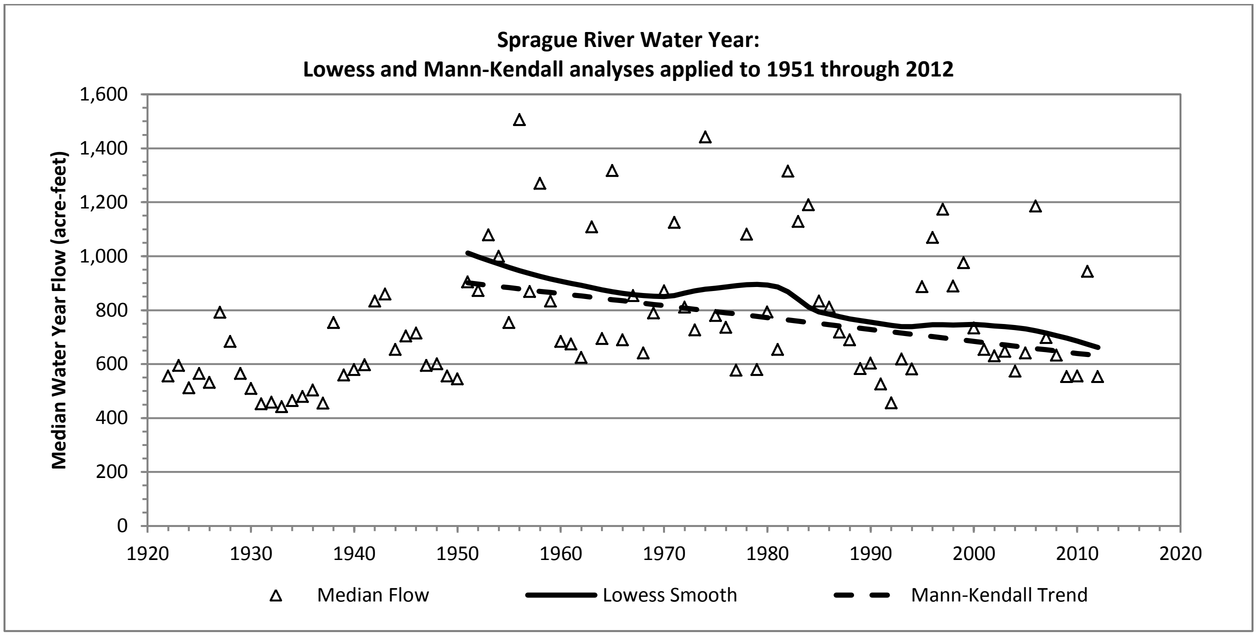

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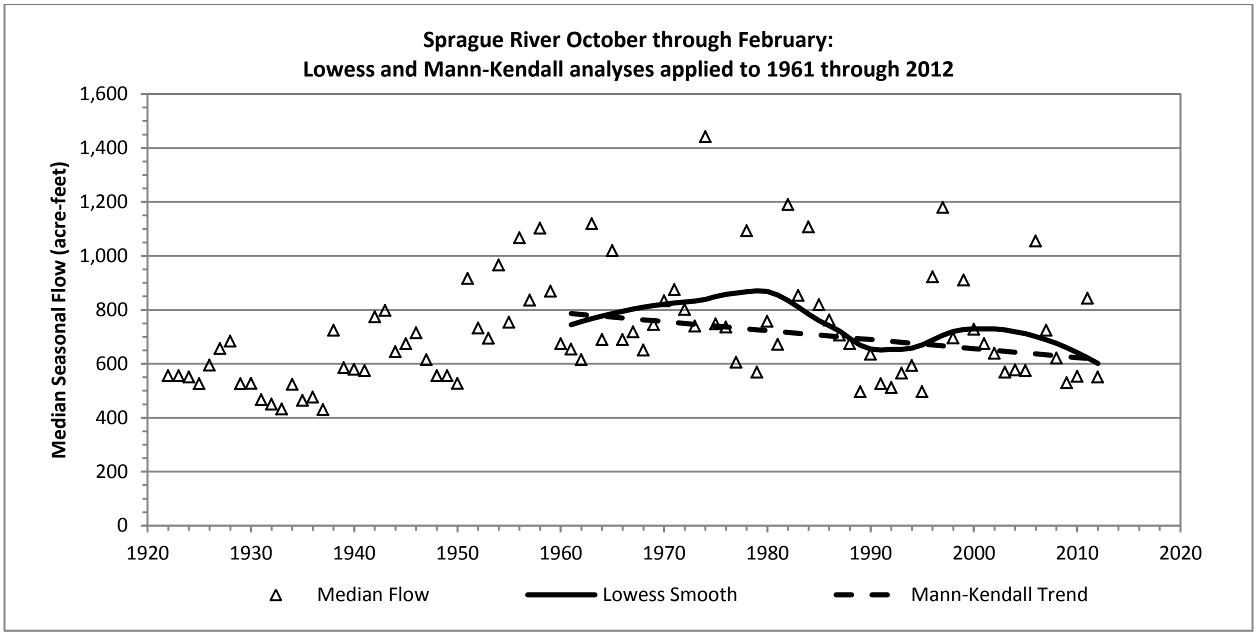
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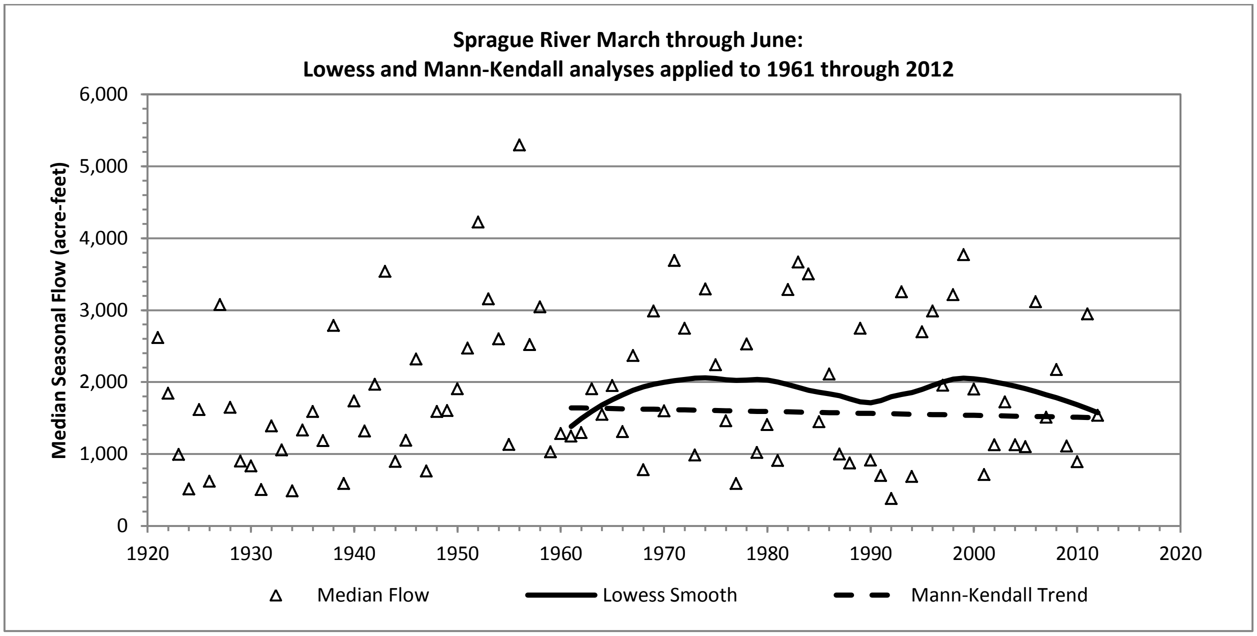
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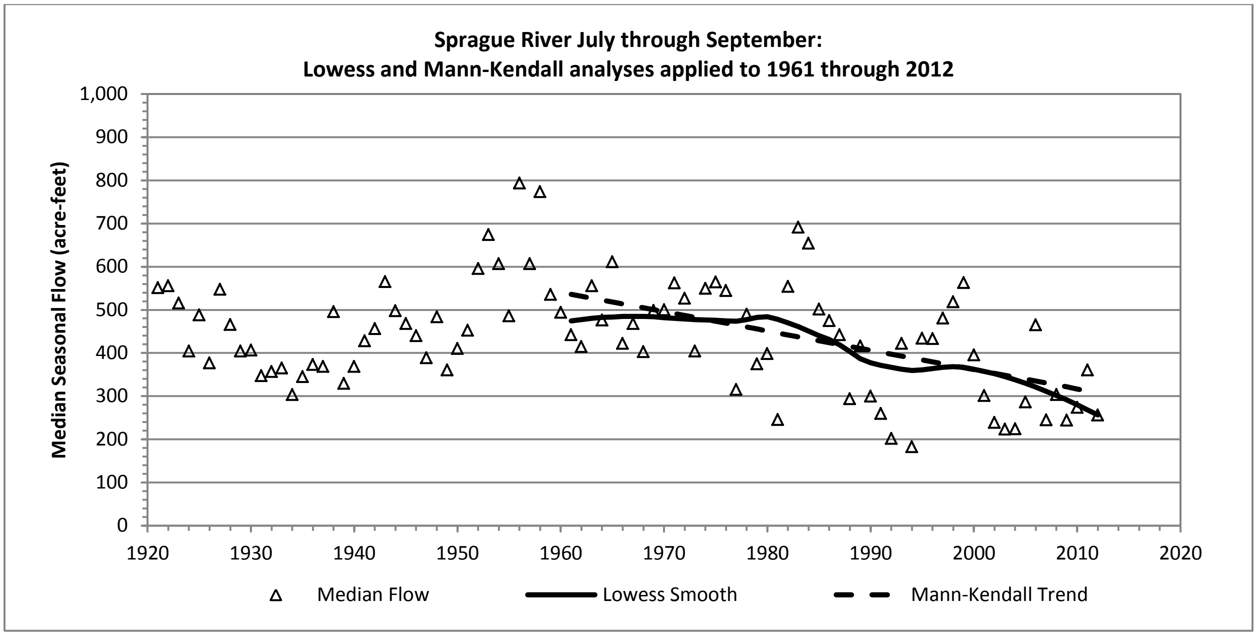
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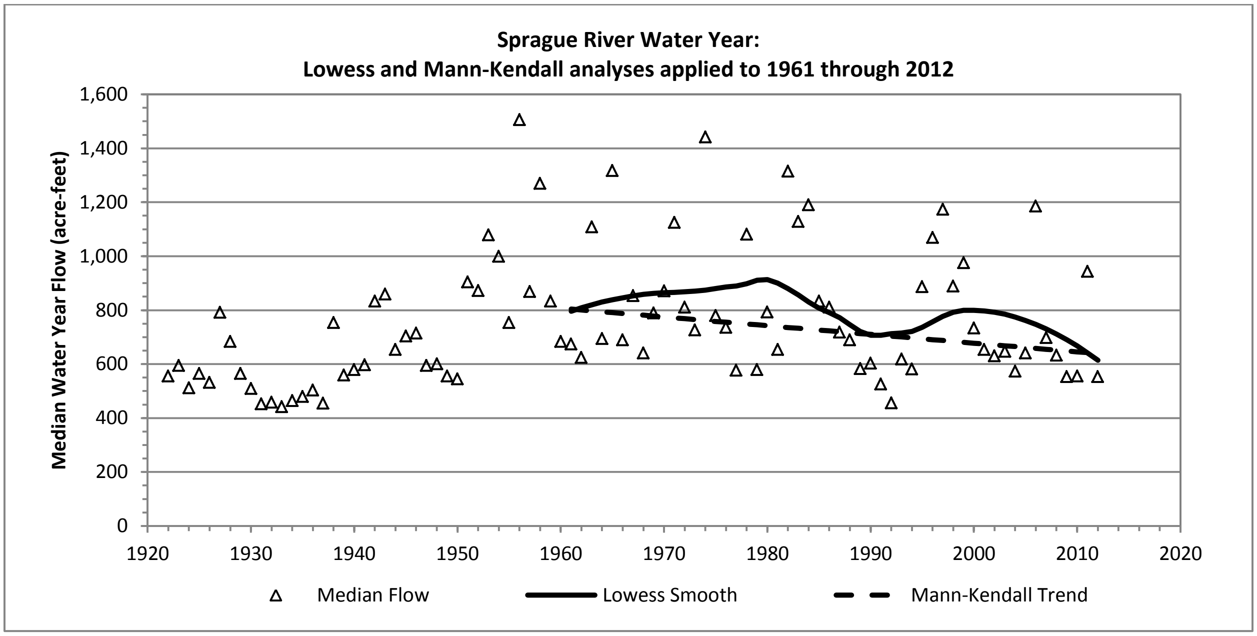
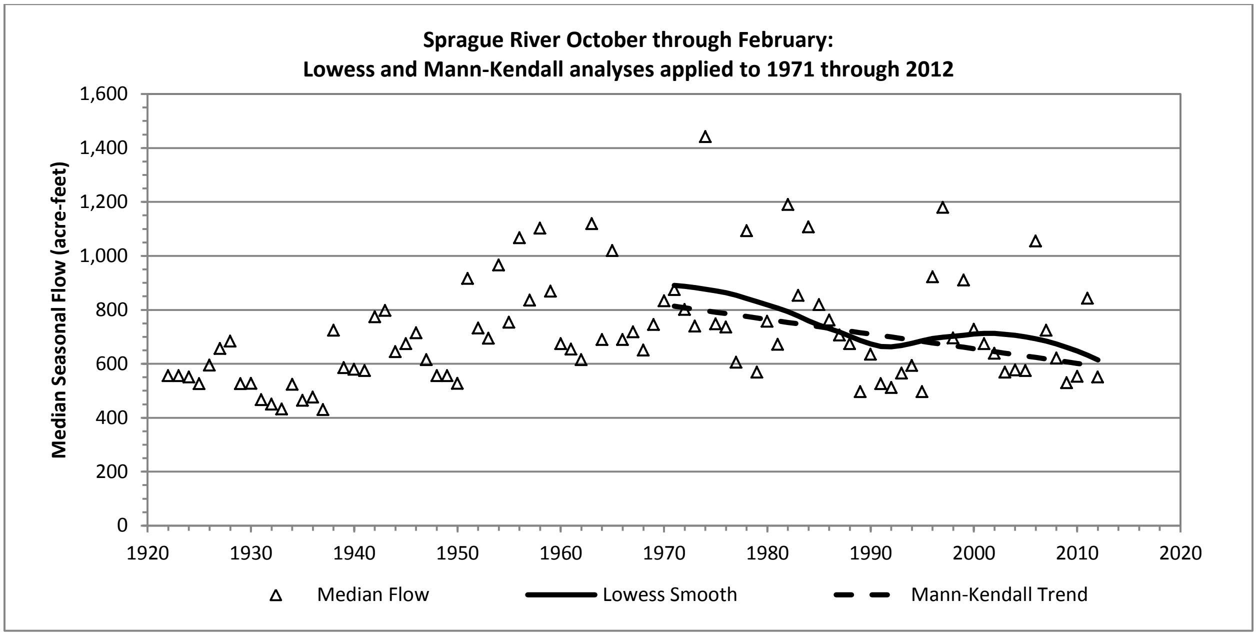
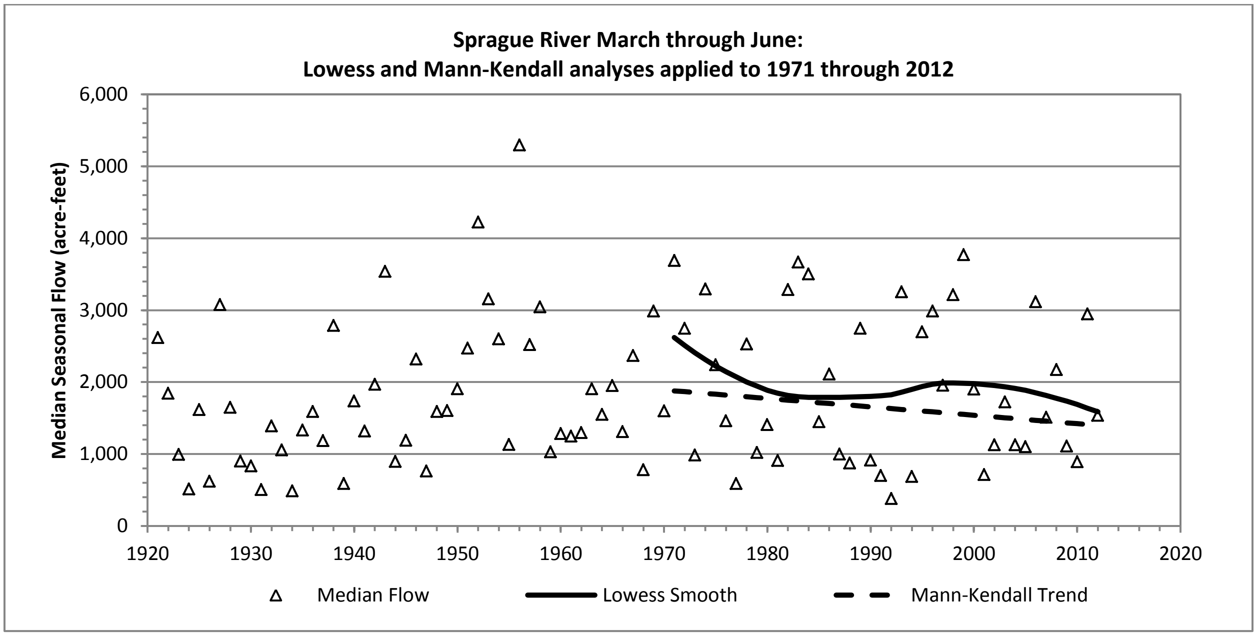
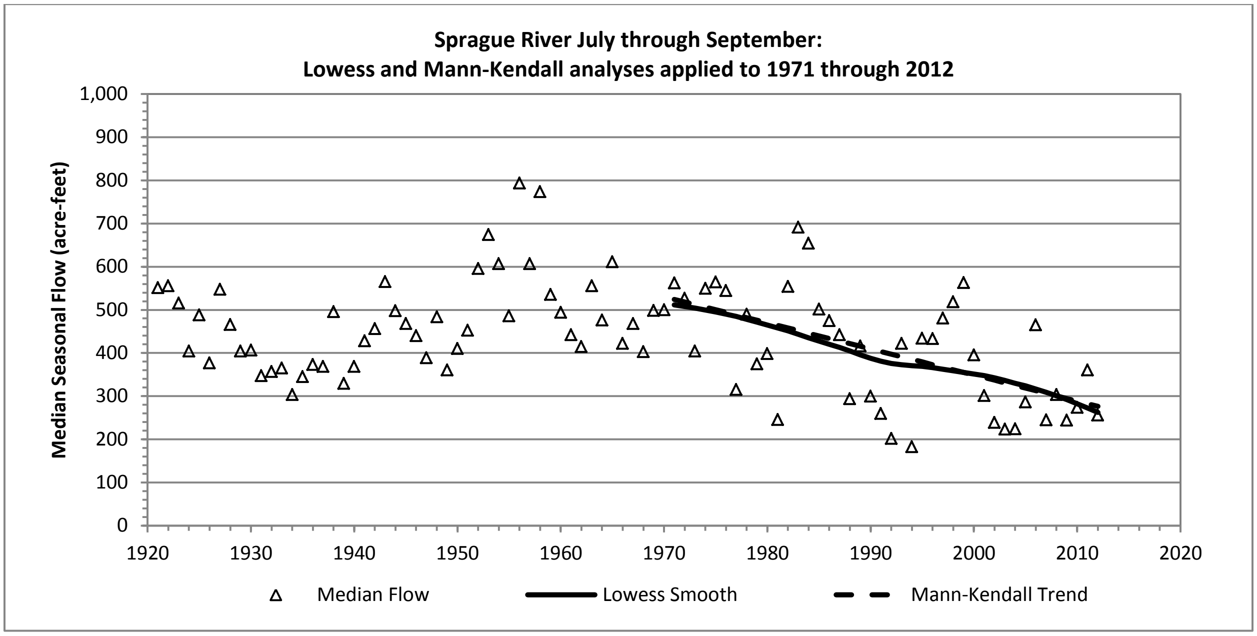
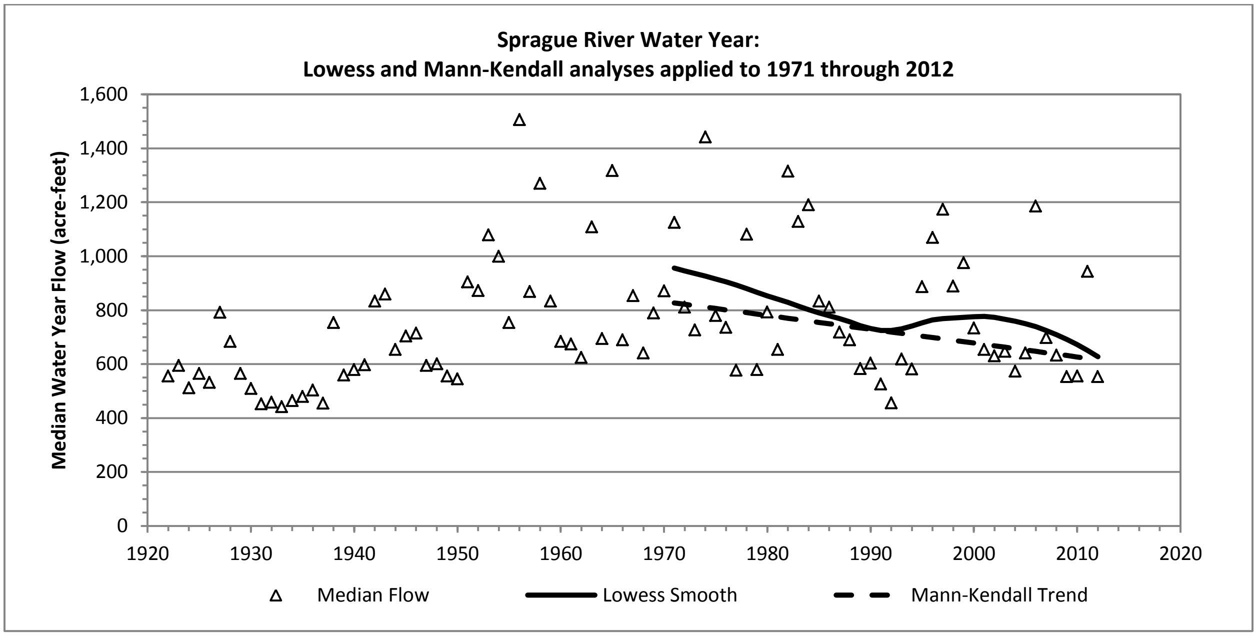
Lowess Smooth
Mann-Kendall Trend


Sprague River Water Year:
Lowess and Mann-Kendall analyses applied to 1961 through 2012
Median Water Year Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River October through February:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River March through June:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River July through September:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
1,000
900
800
700
600
500
400
300
200
100
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River Water Year:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Water Year Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
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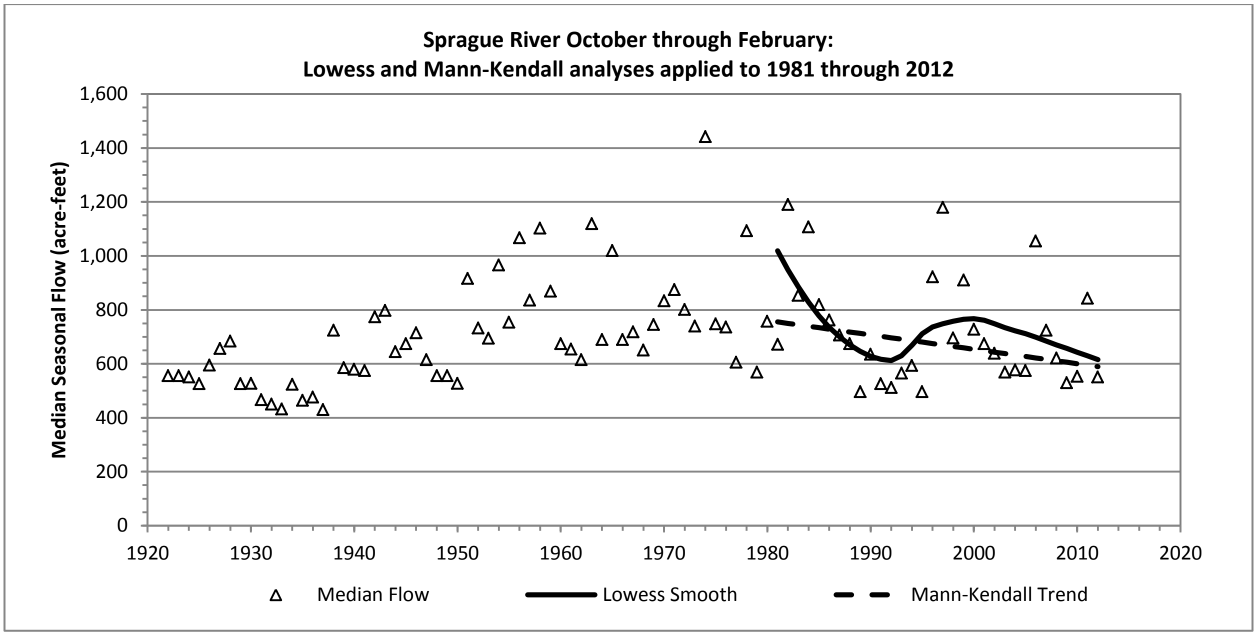
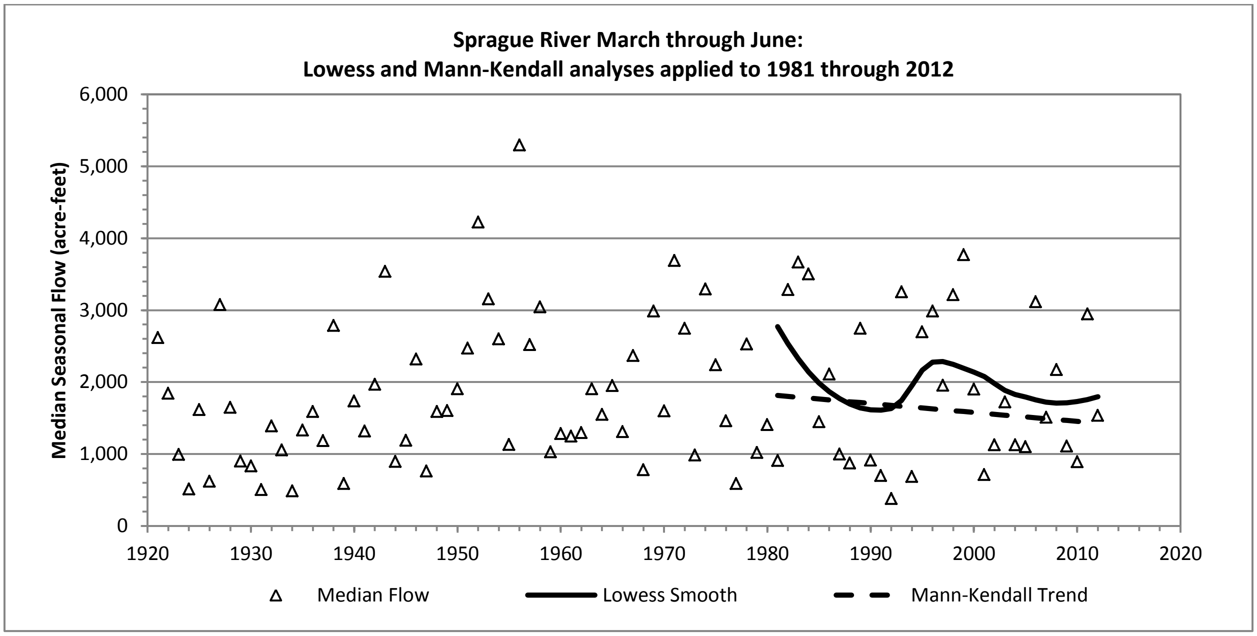
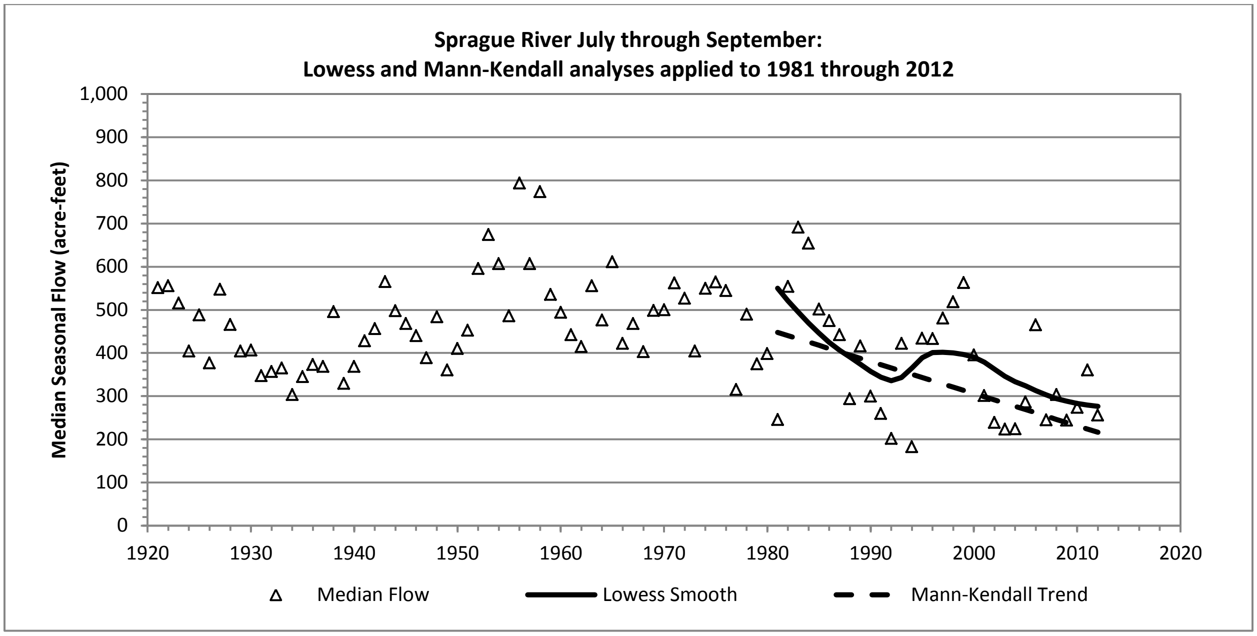
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River October through February:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River March through June:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend



Sprague River July through September:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
1,000
900
800
700
600
500
400
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200
100
0
1920
1930
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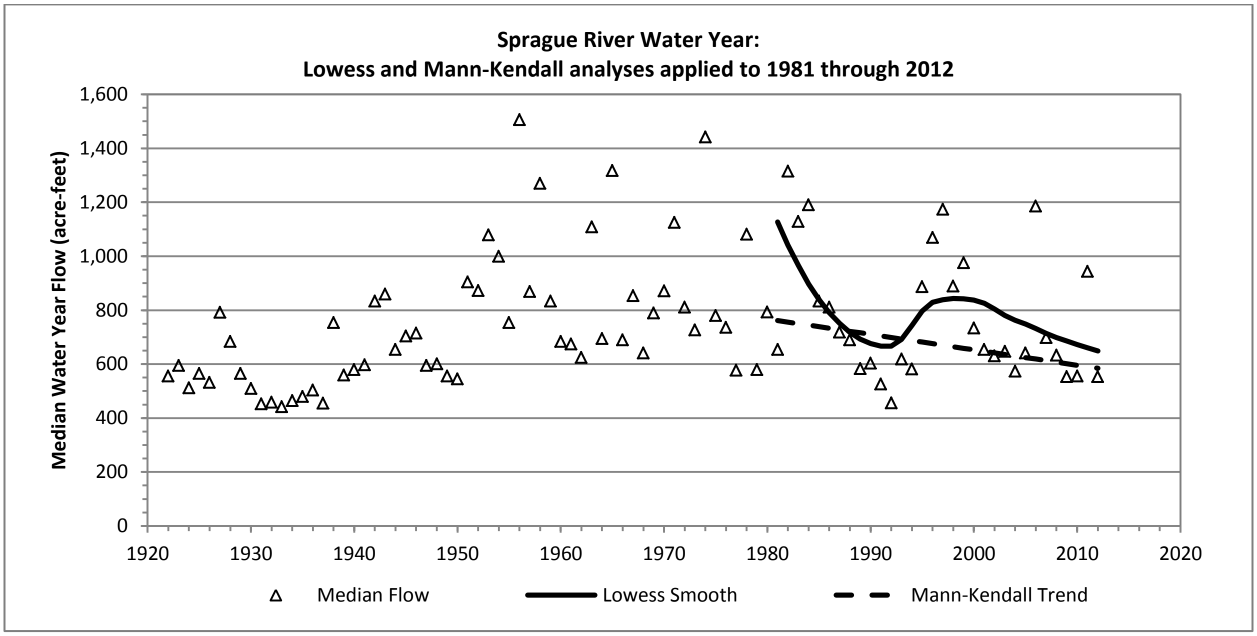
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend



Sprague River Water Year:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Water Year Flow (acre-feet)
1,600
1,400
1,200
1,000
800
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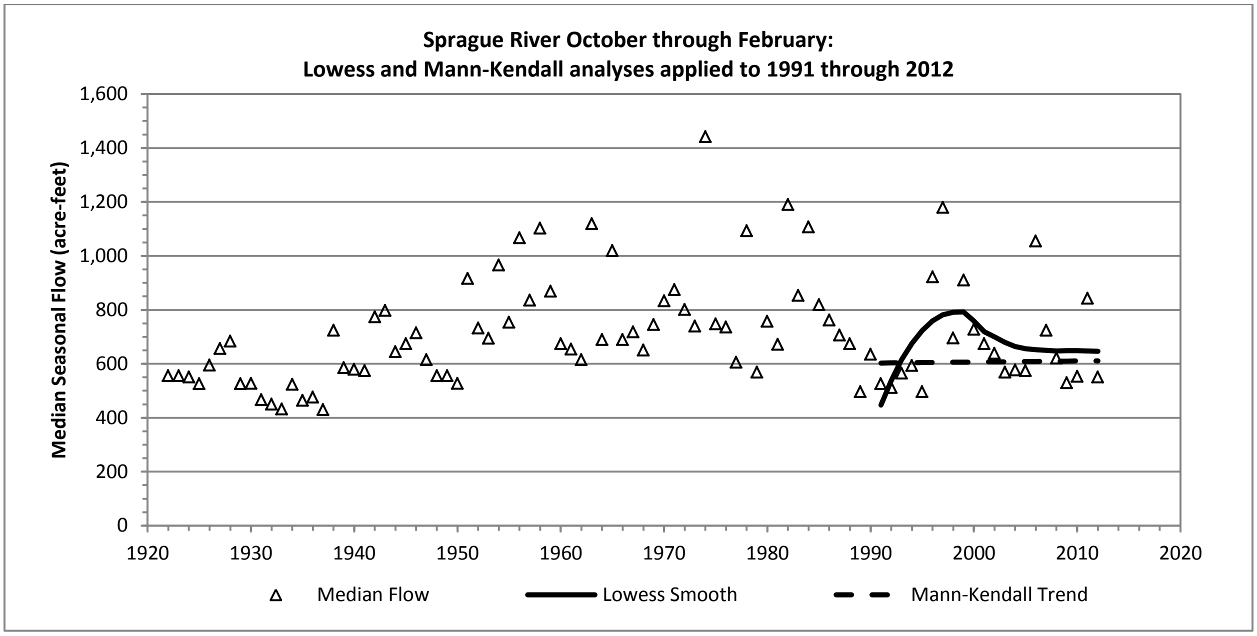
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River October through February:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
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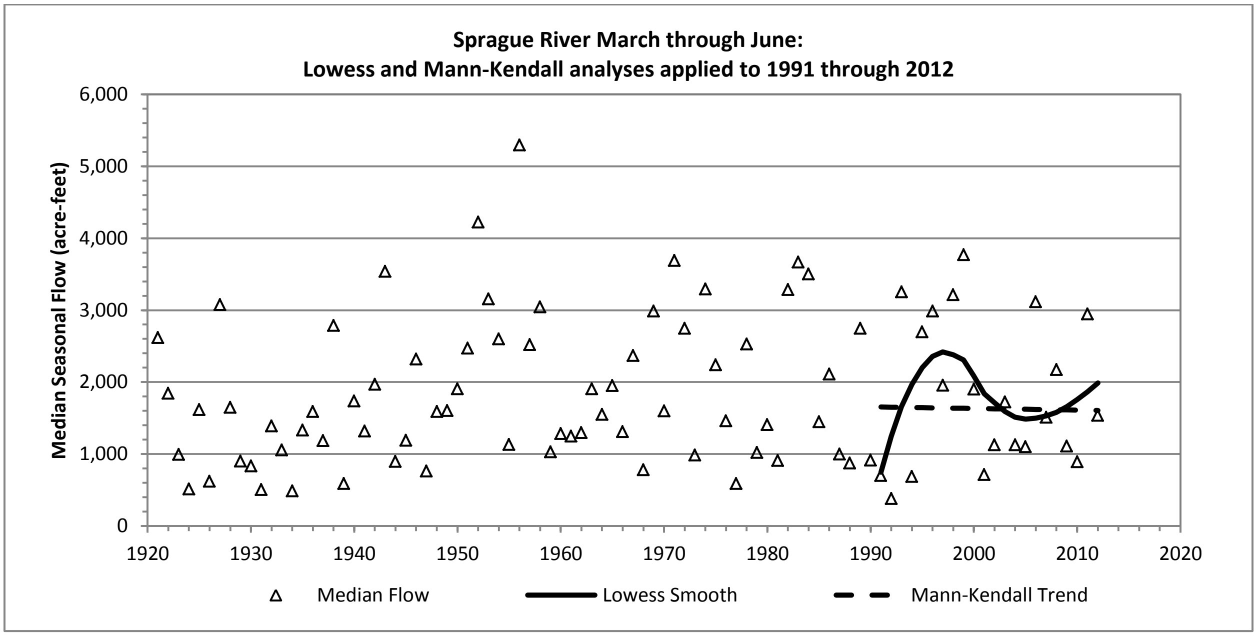
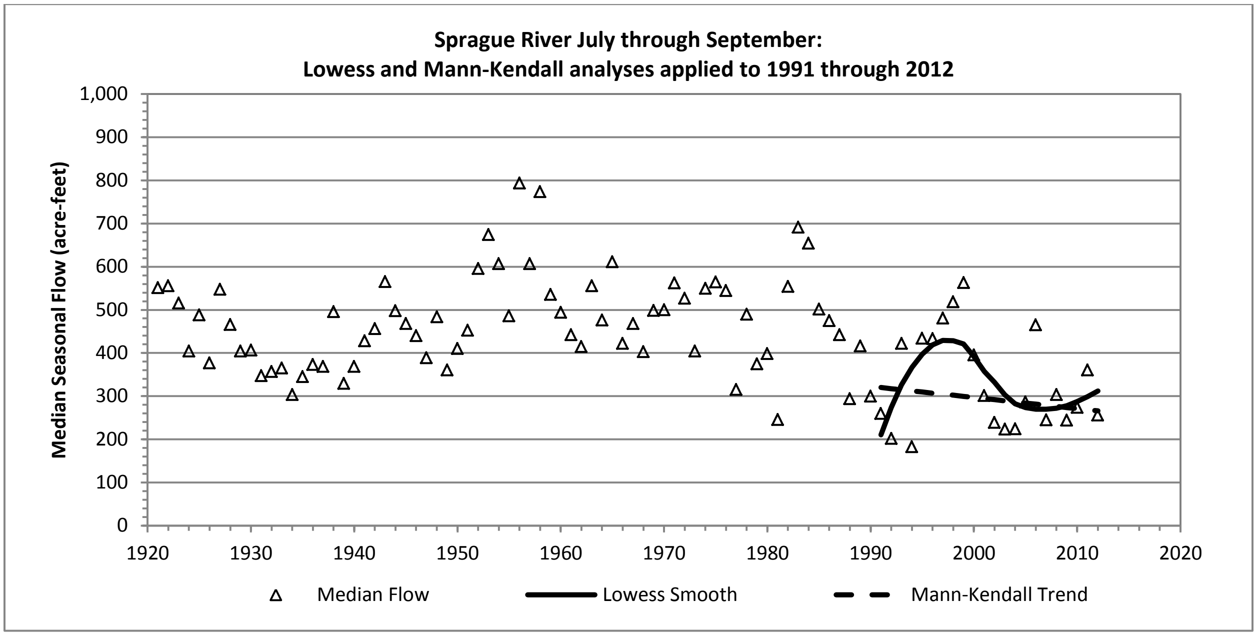
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River March through June:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River July through September:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
1,000
900
800
700
600
500
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300
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100
0
1920
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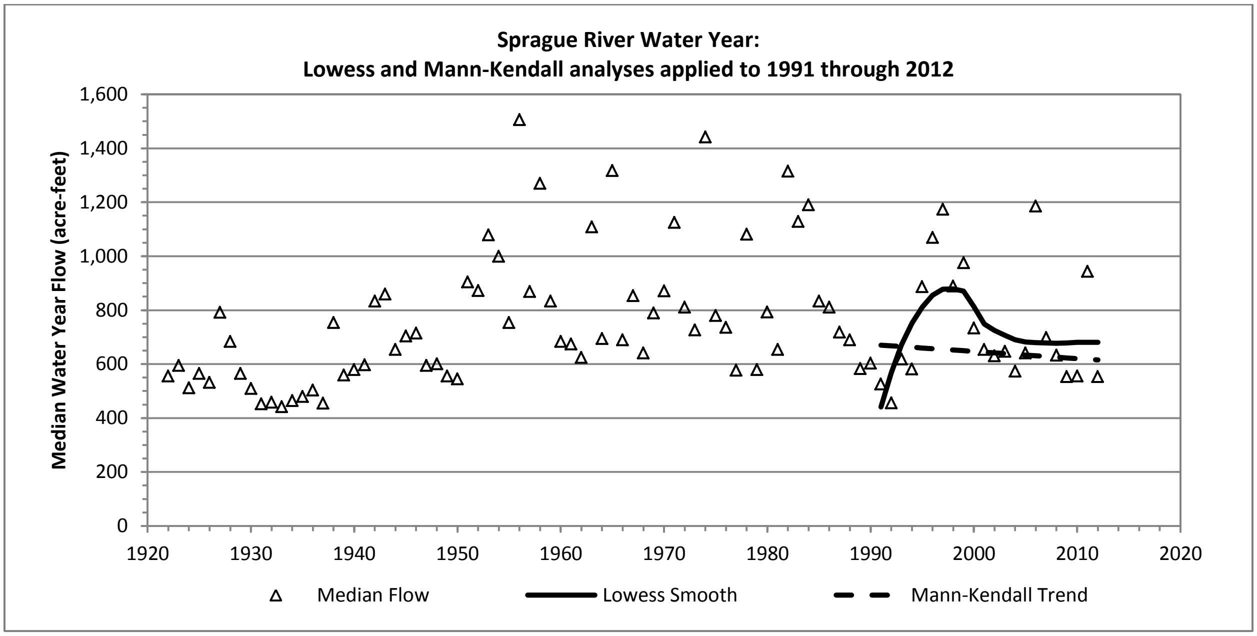
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Sprague River Water Year:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Water Year Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
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0
1920
1930
1940
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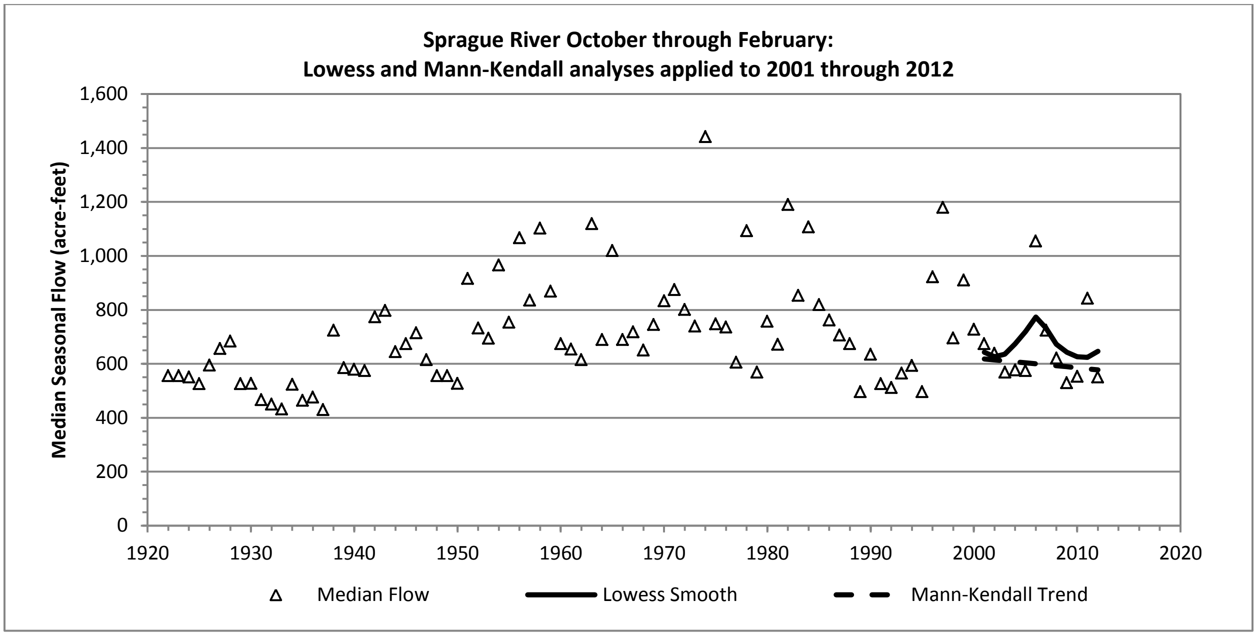
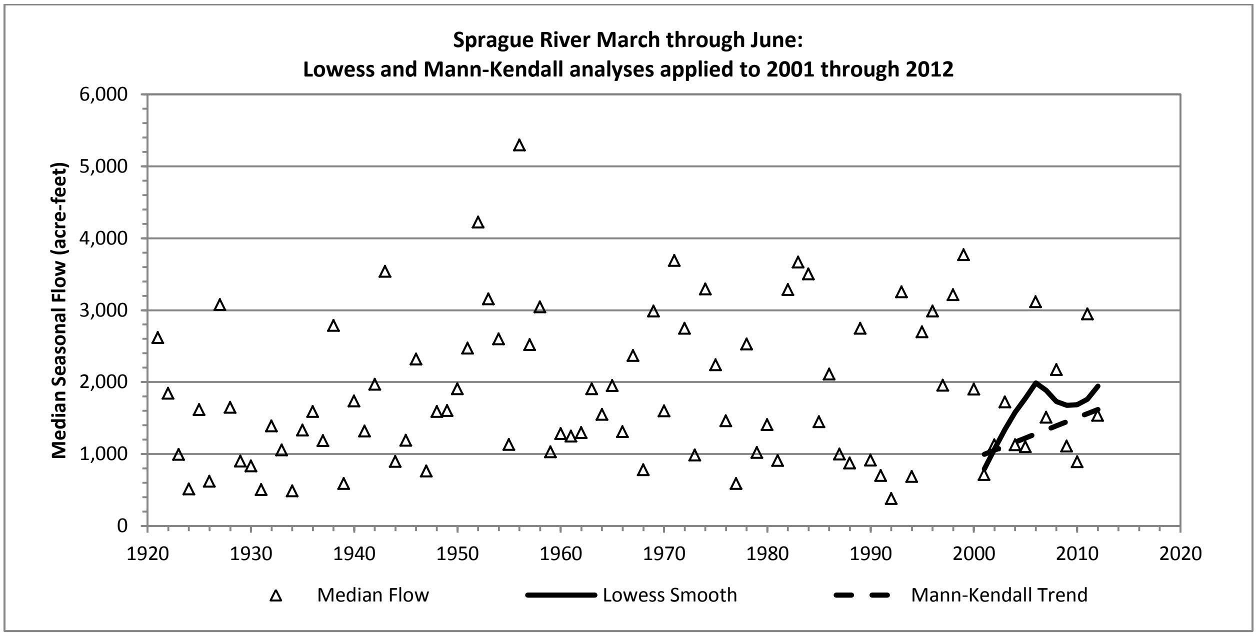
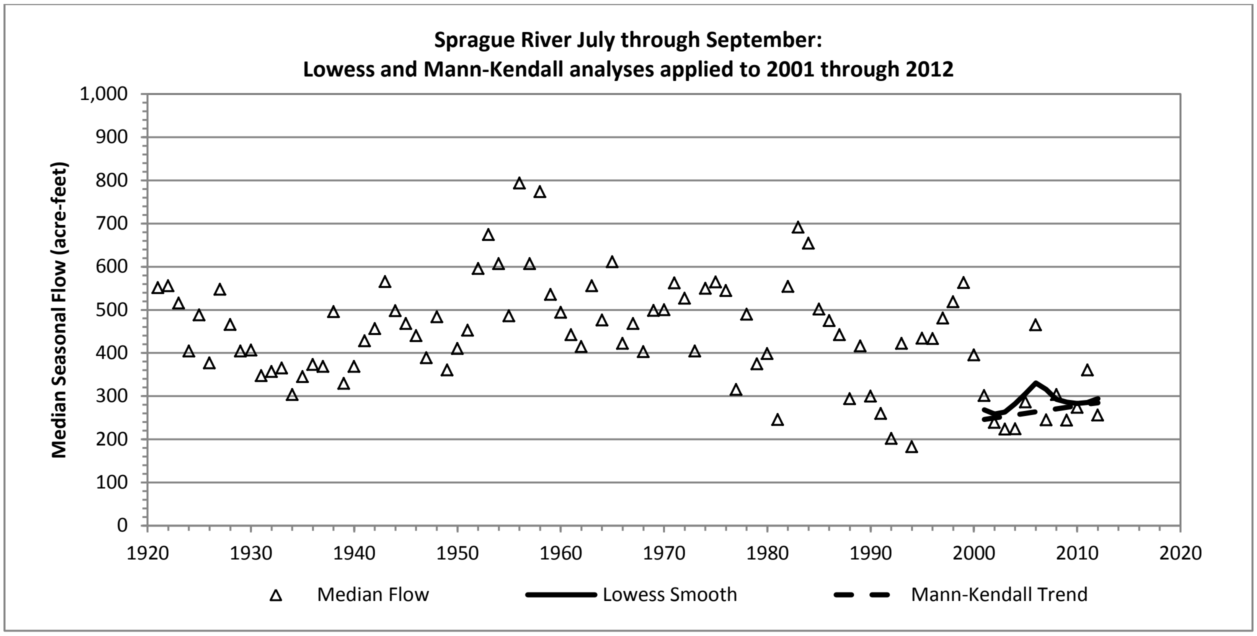
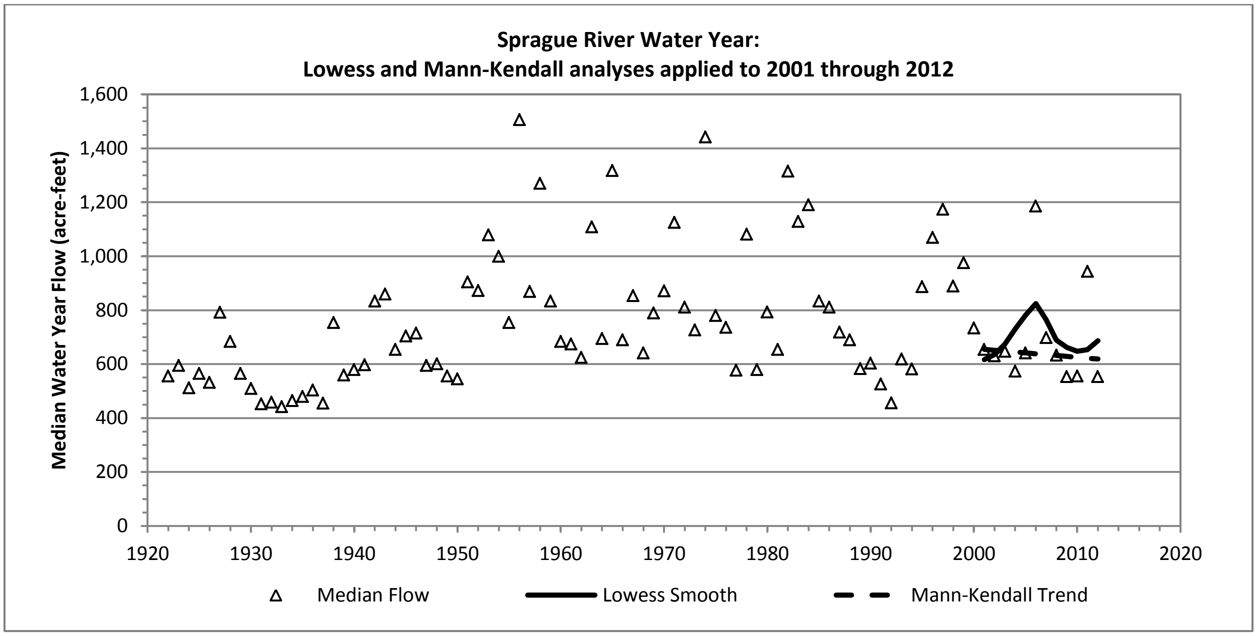
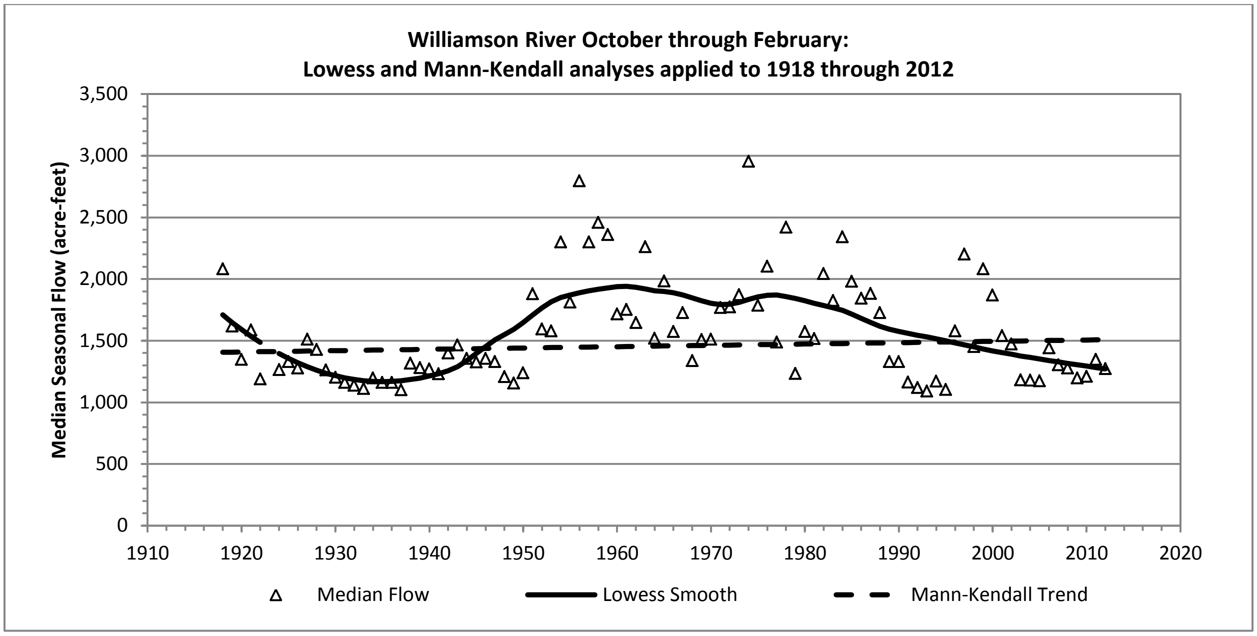
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend

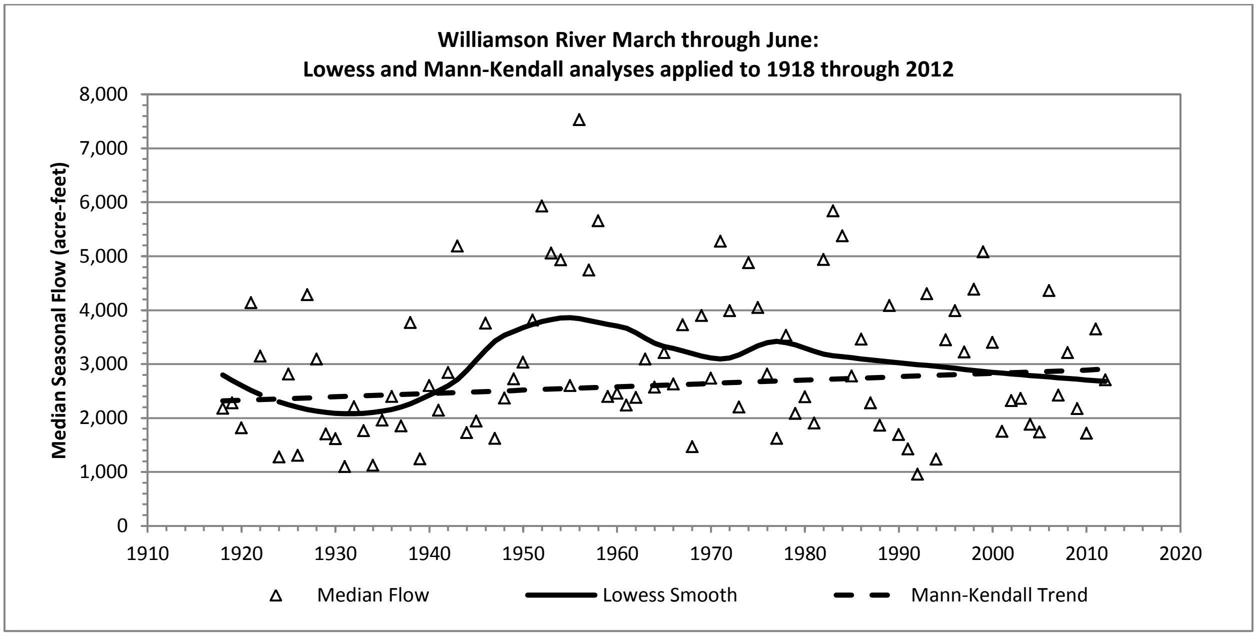

Sprague River October through February:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend

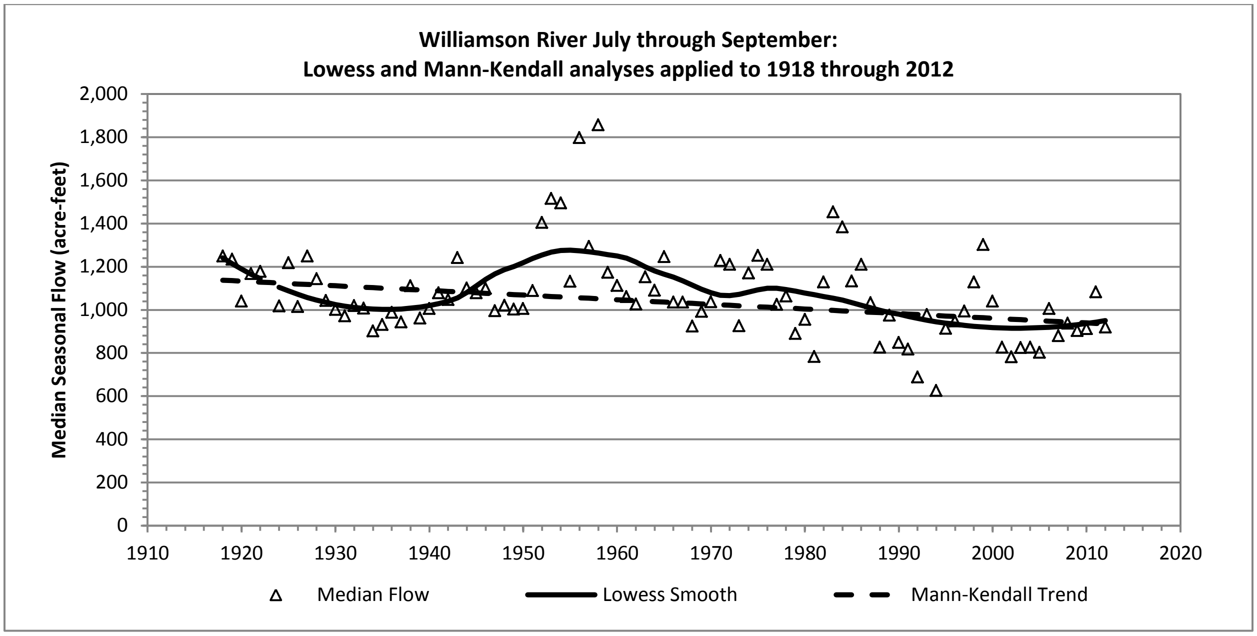

Sprague River March through June:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend

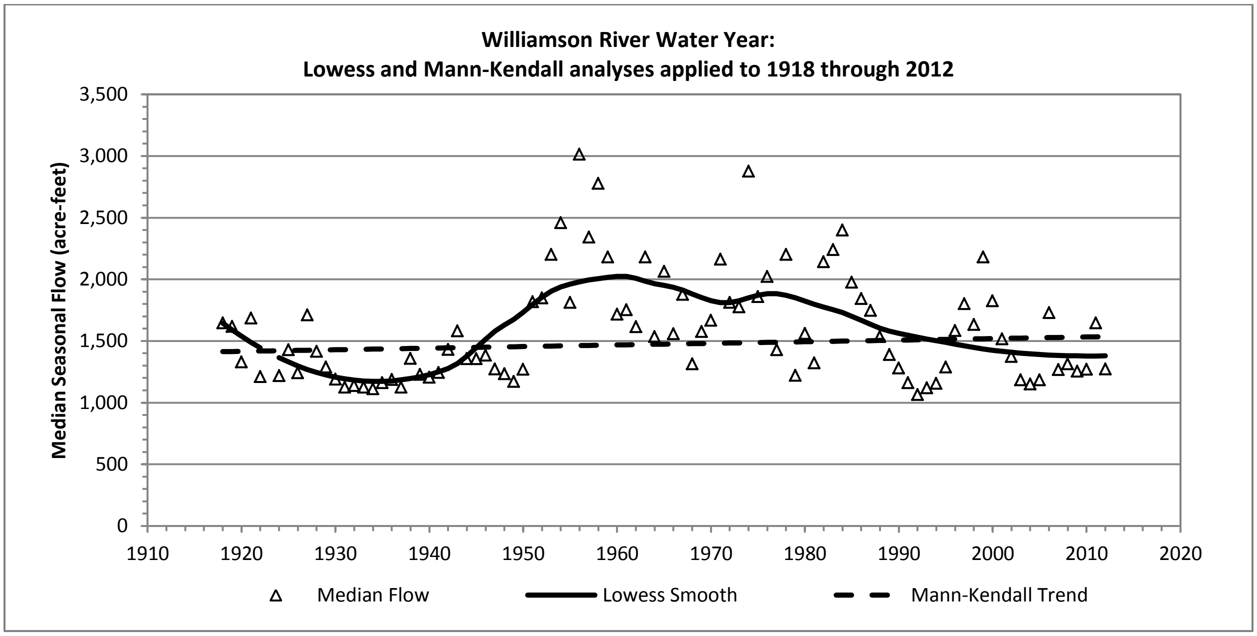

Sprague River July through September:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
1,000
900
800
700
600
500
400
300
200
100
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend

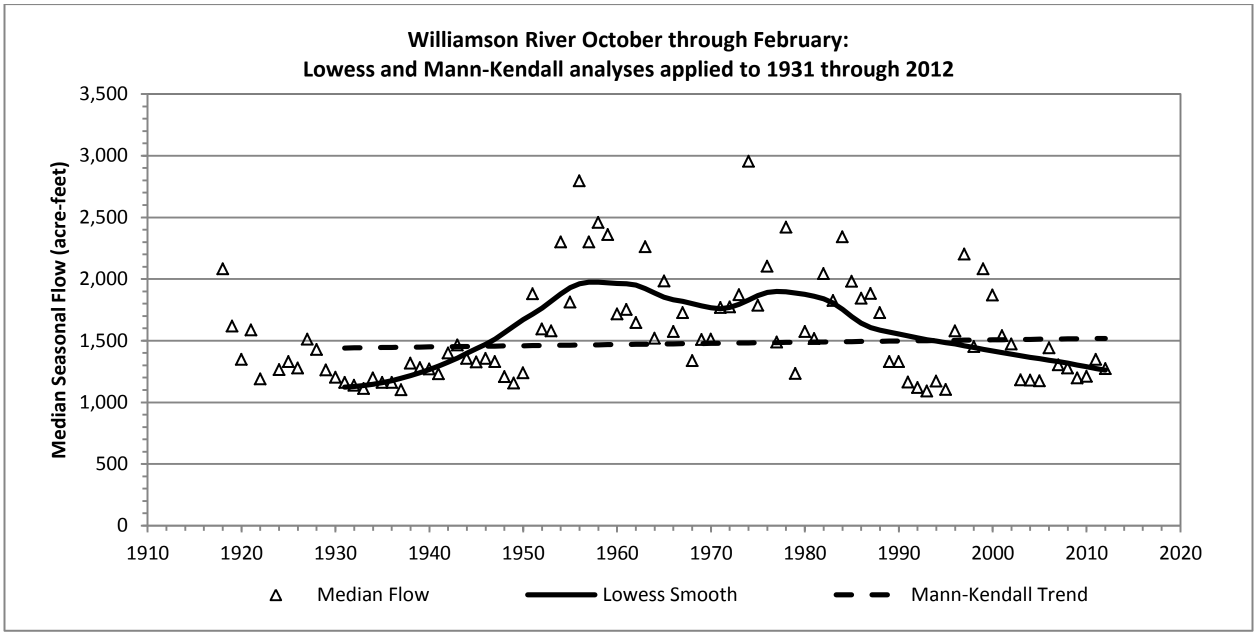

Sprague River Water Year:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Water Year Flow (acre-feet)
1,600
1,400
1,200
1,000
800
600
400
200
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend

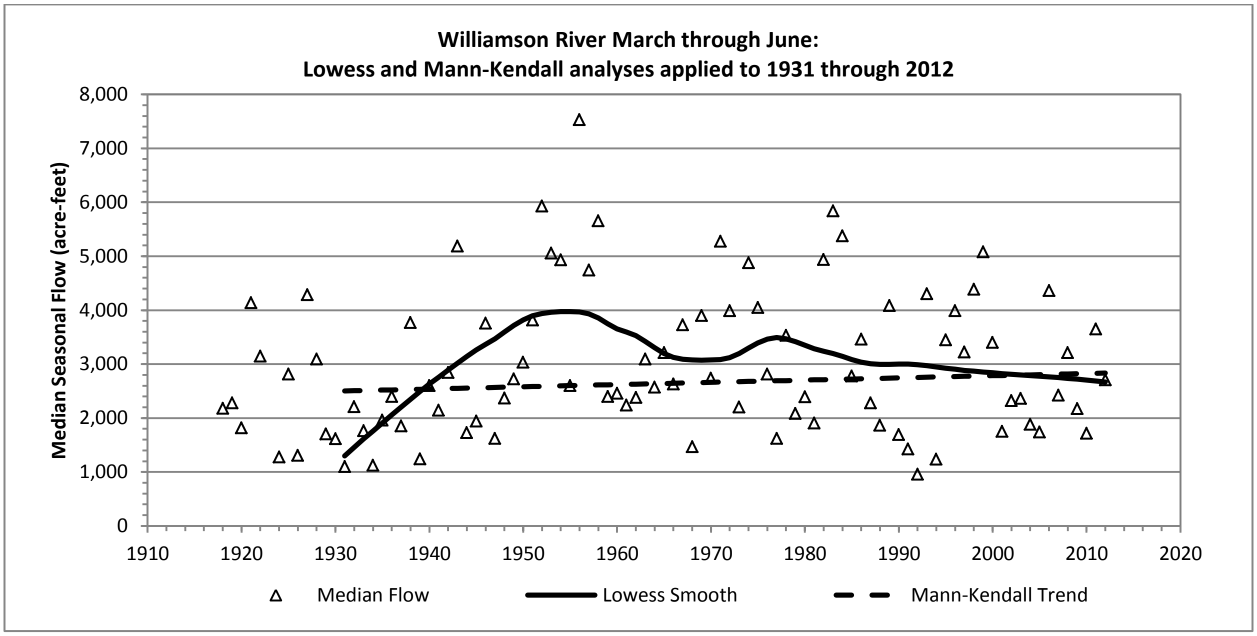

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1918 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

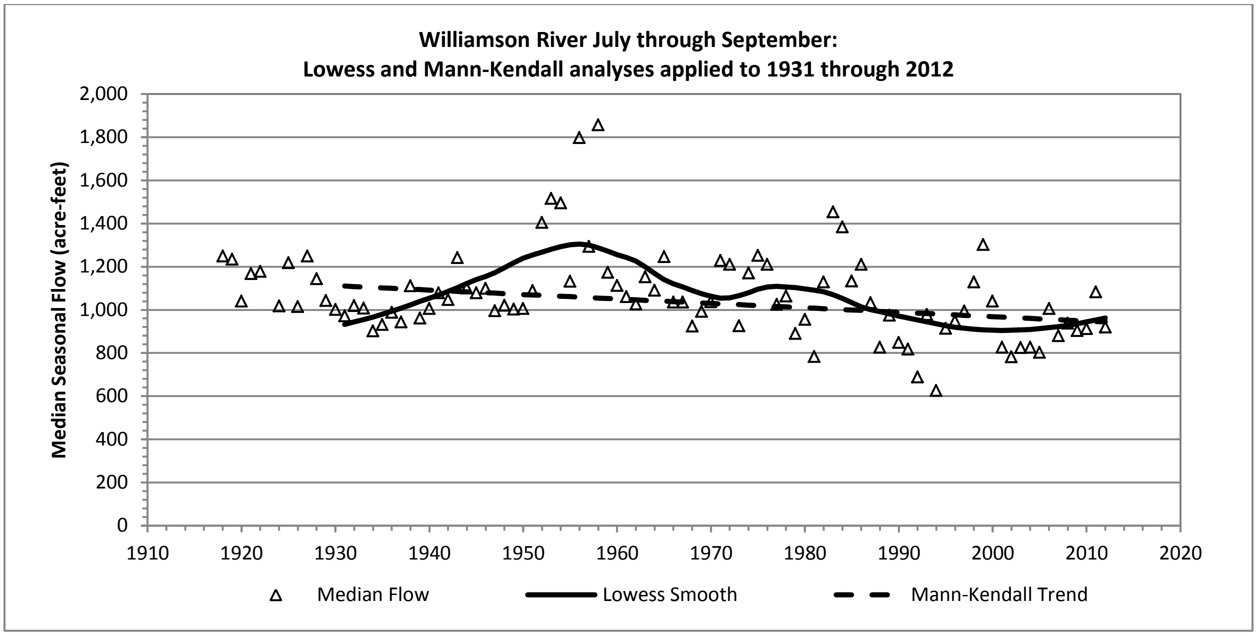

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1918 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

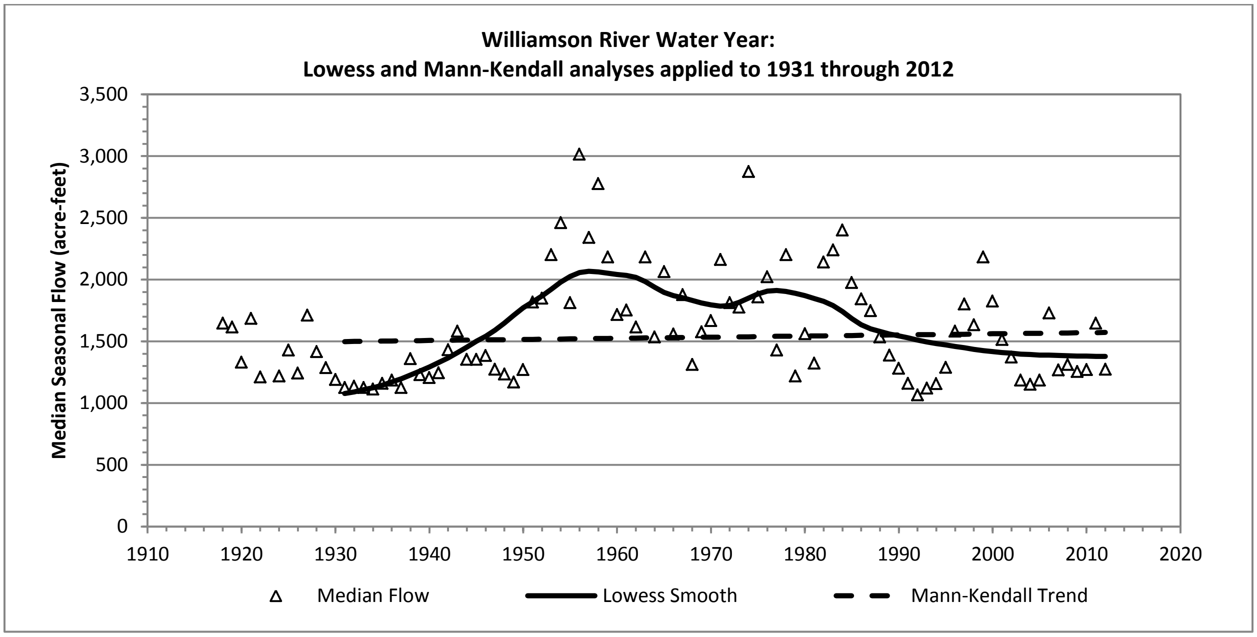

Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1918 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

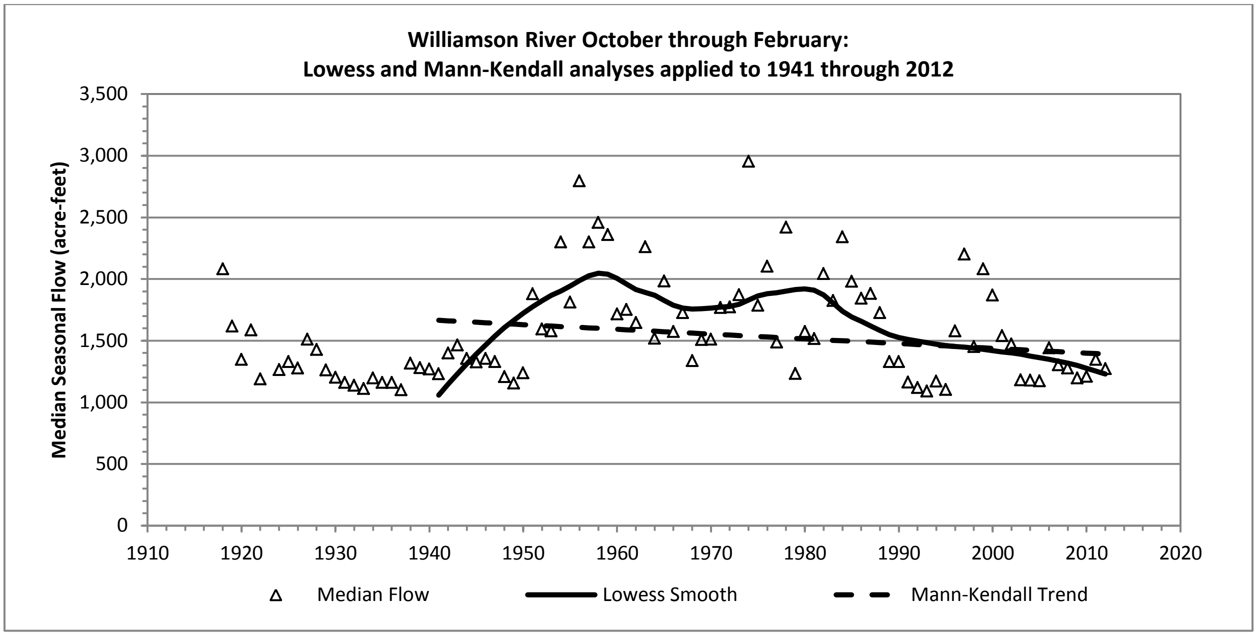

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1918 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

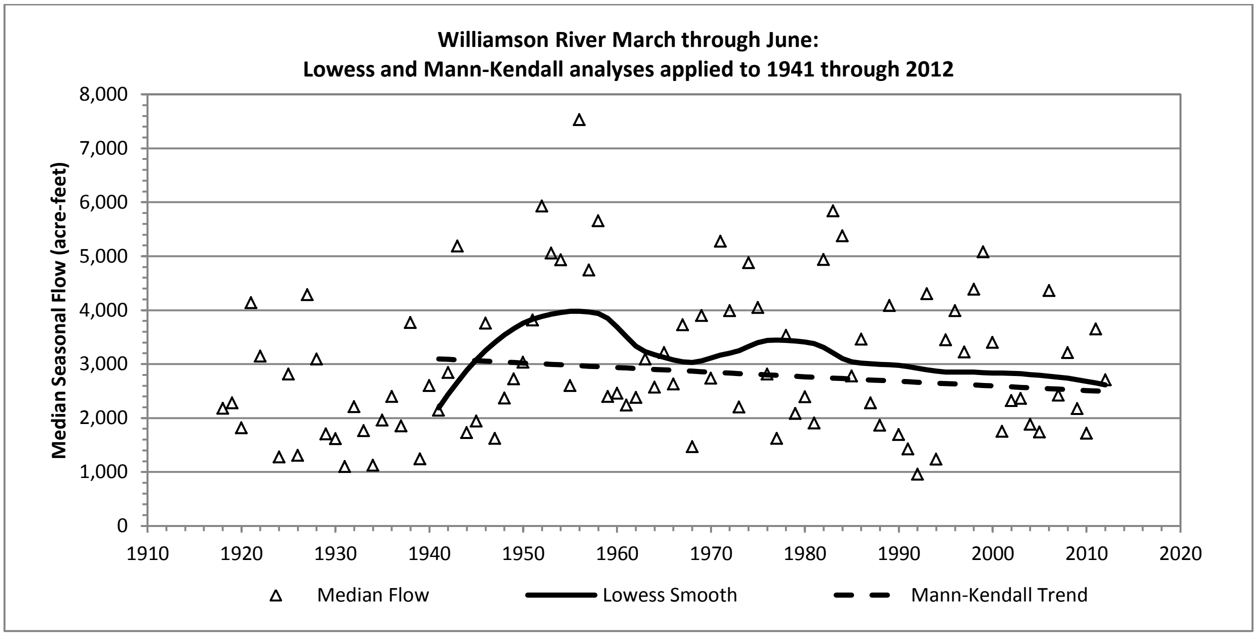

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1931 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

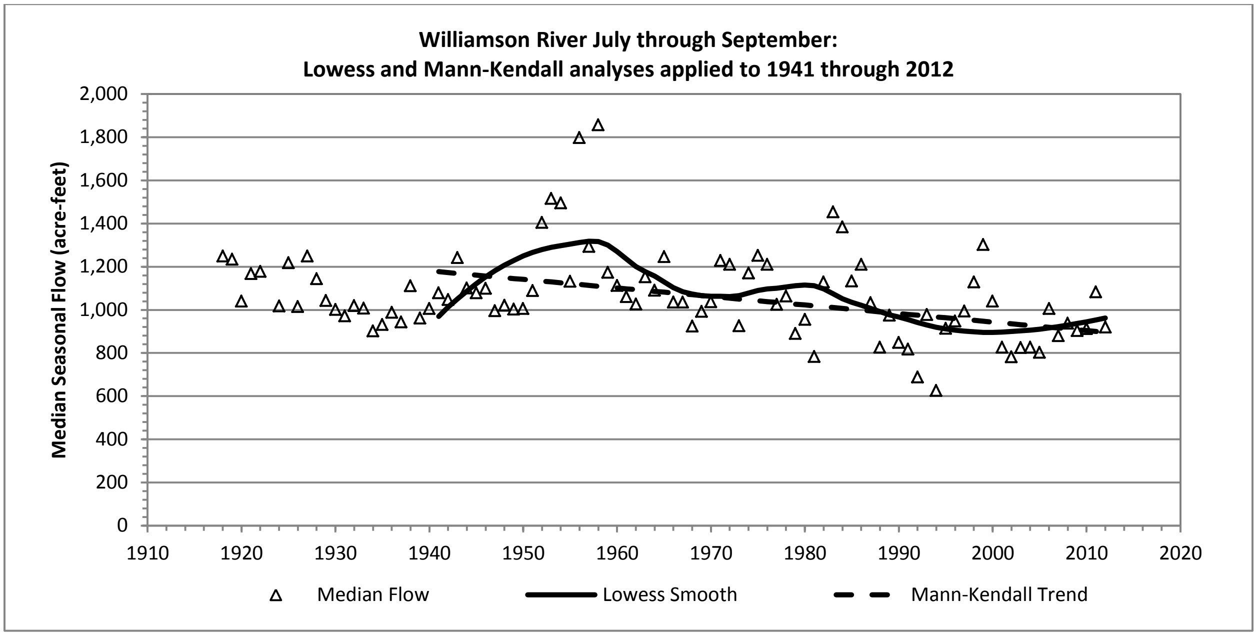

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1931 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

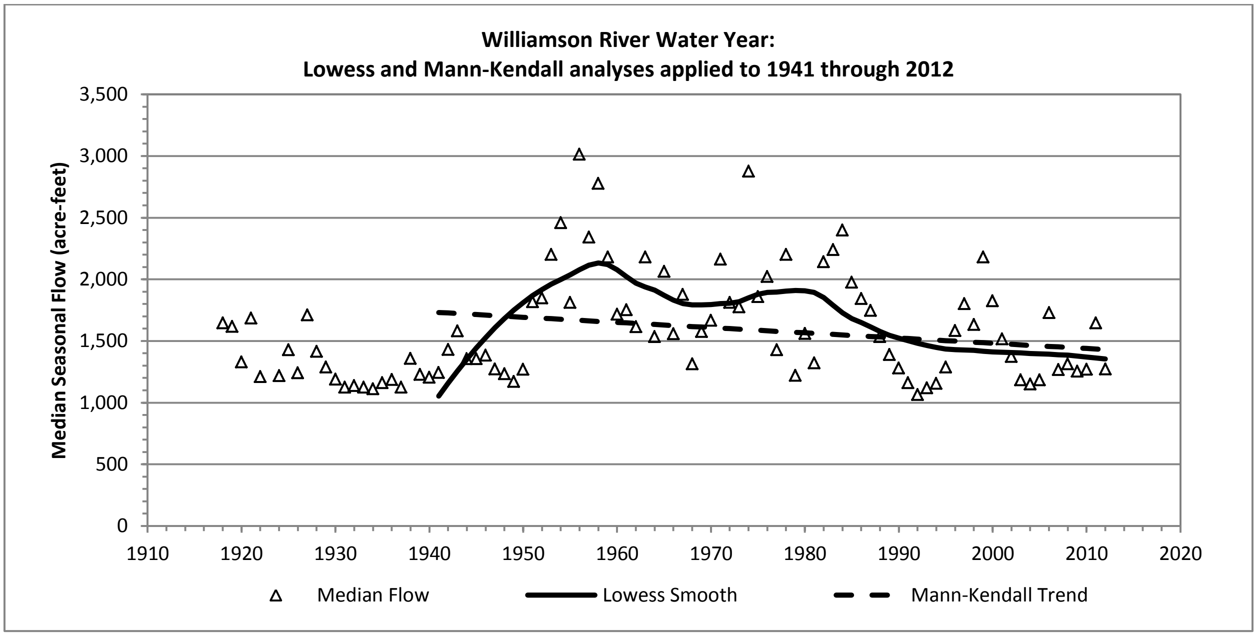

Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1931 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

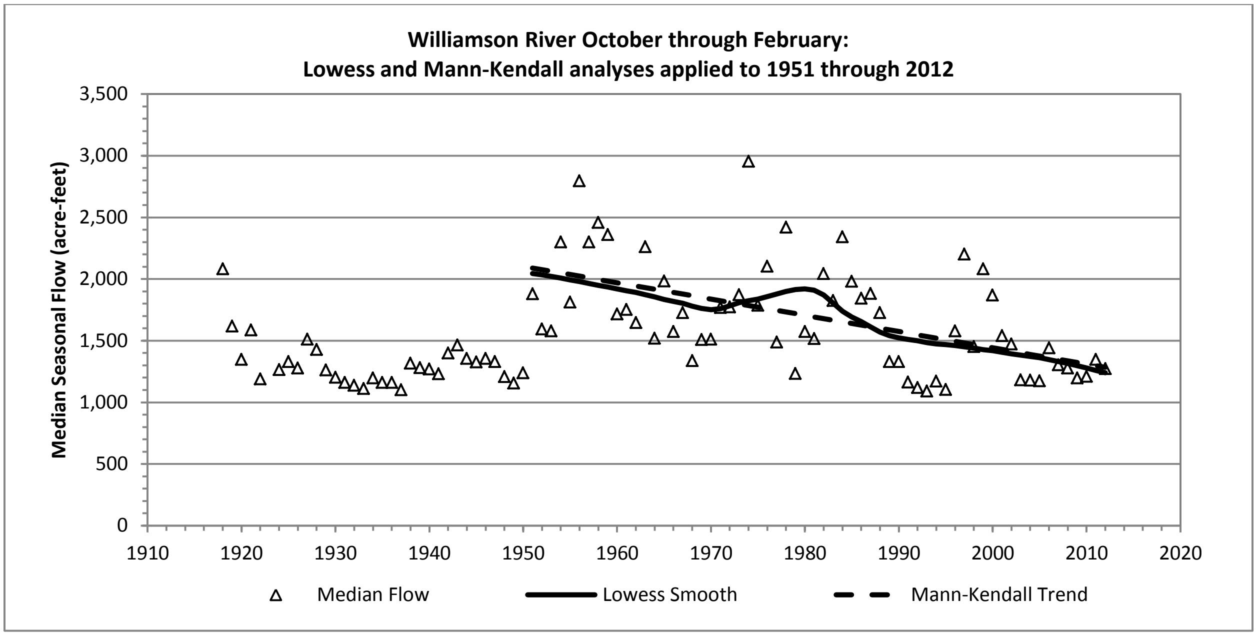

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1931 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

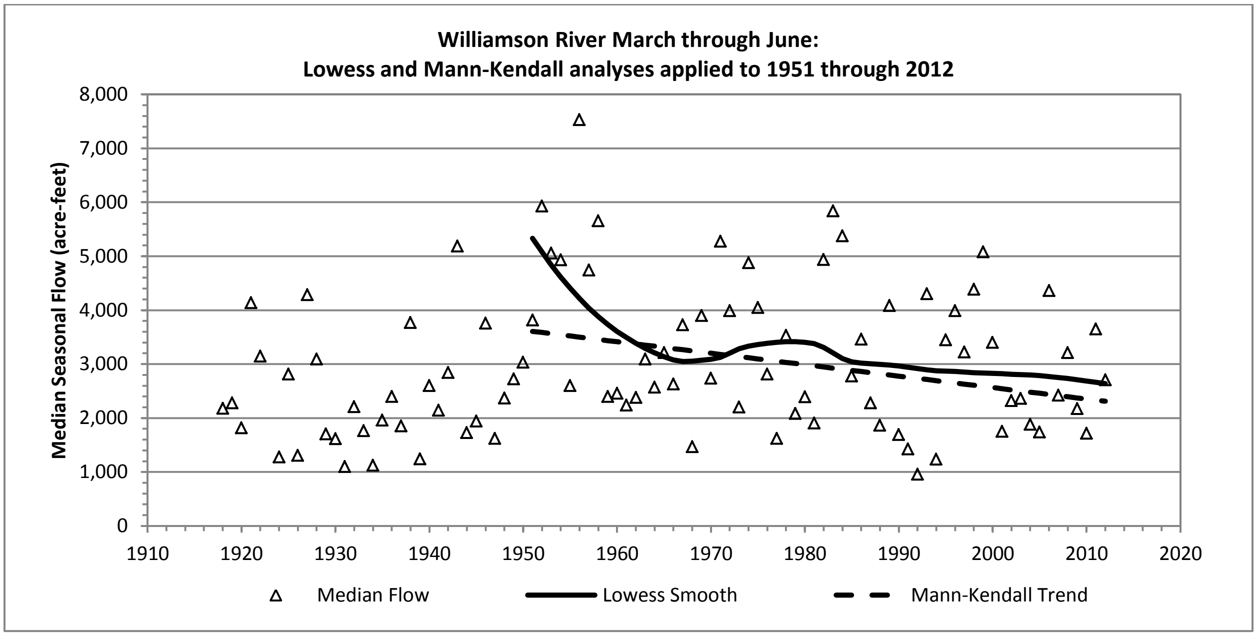

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1941 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1941 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1941 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Δ Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1941 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Δ Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1951 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1951 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
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1970
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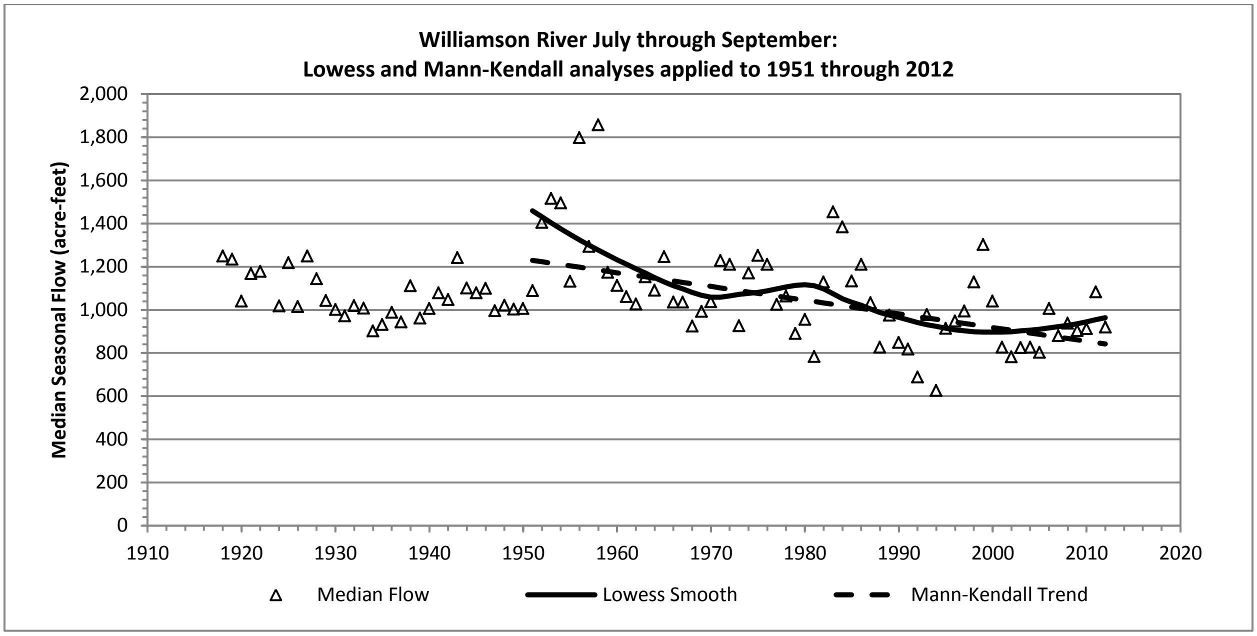
2010
2020
△ Median Flow
Lowess Smooth
Mann-Kendall Trend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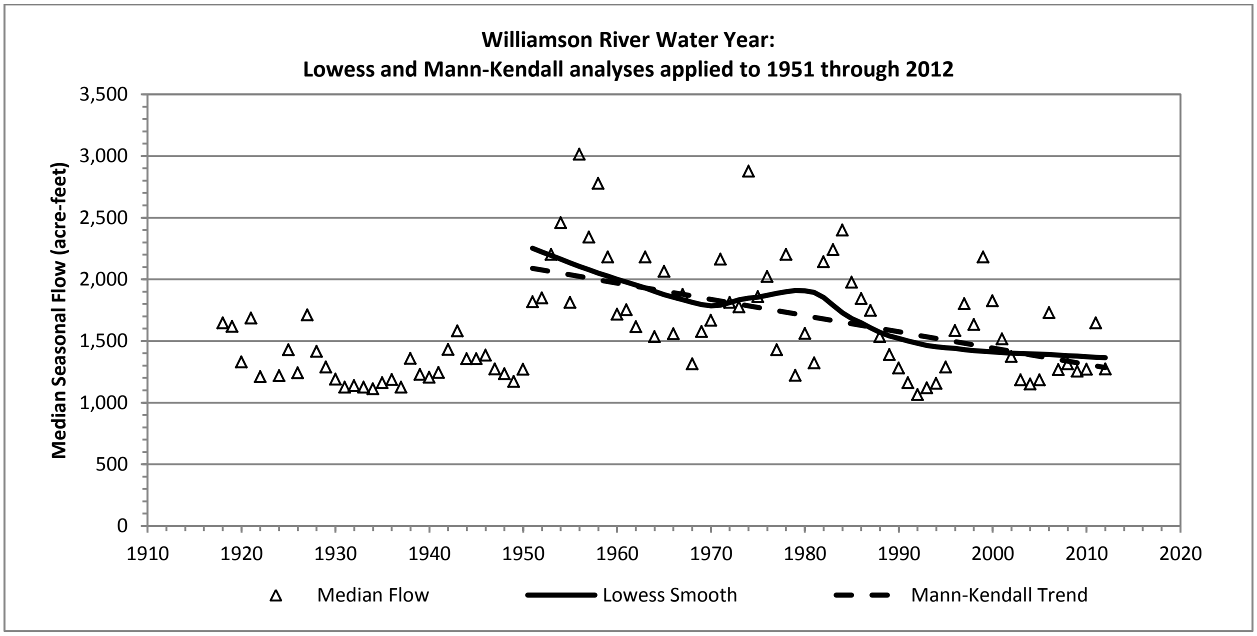
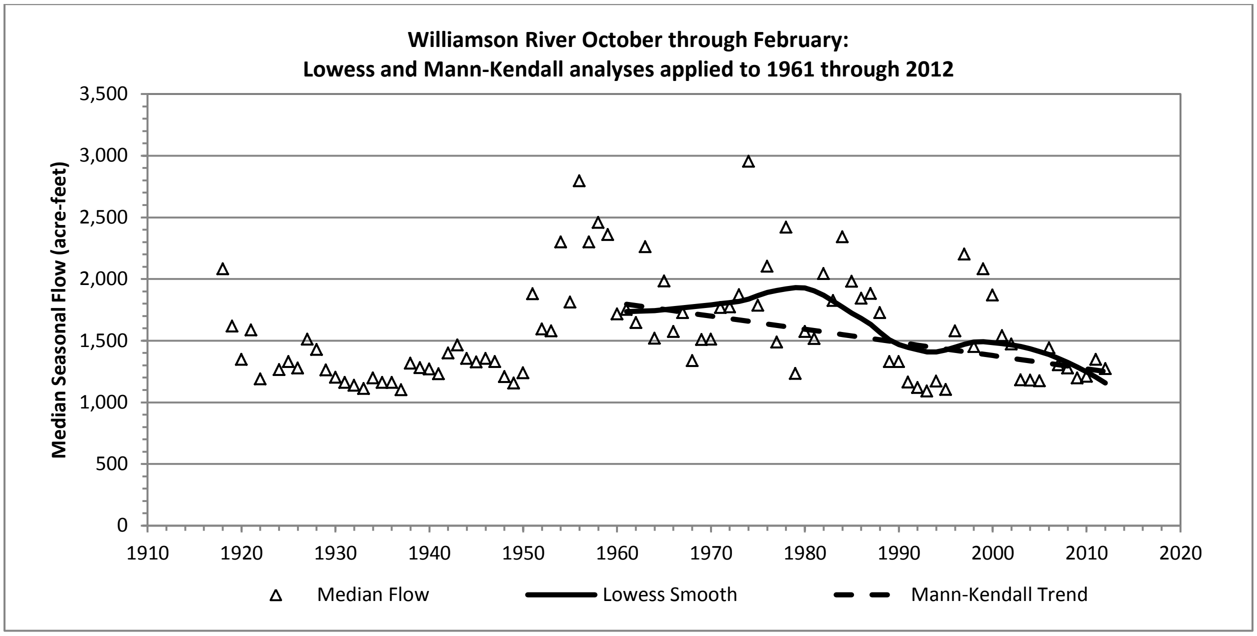
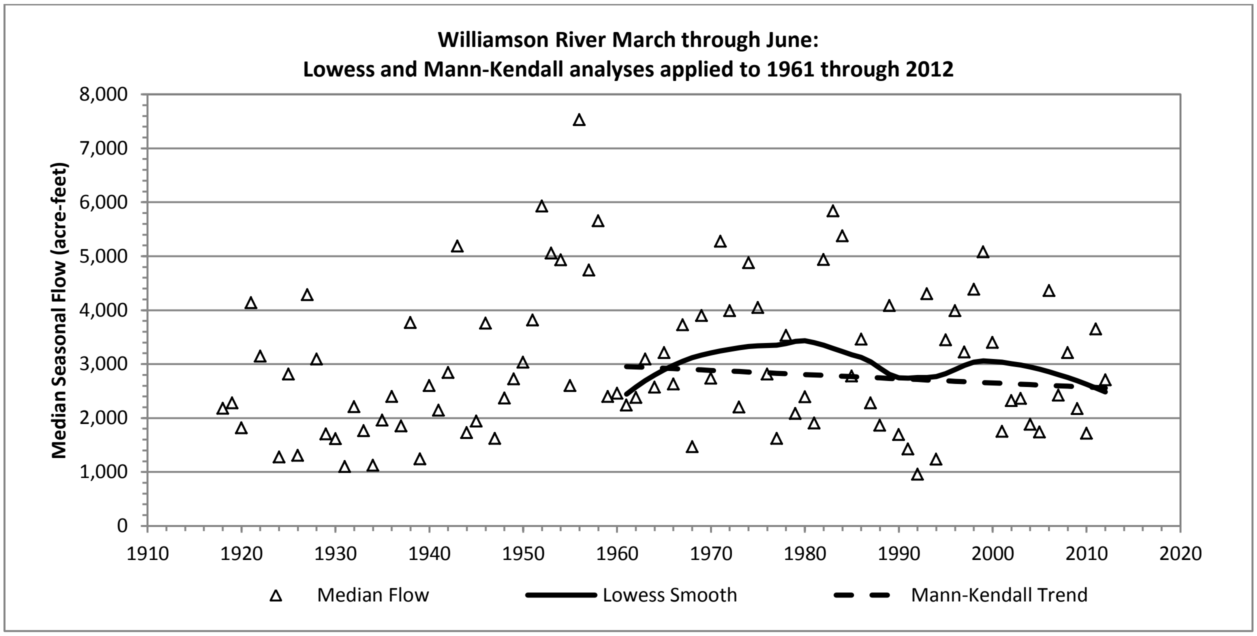
Lowess and Mann-Kendall analyses applied to 1951 through 2012


Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1951 through 2012


Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1961 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1961 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
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1910
1920
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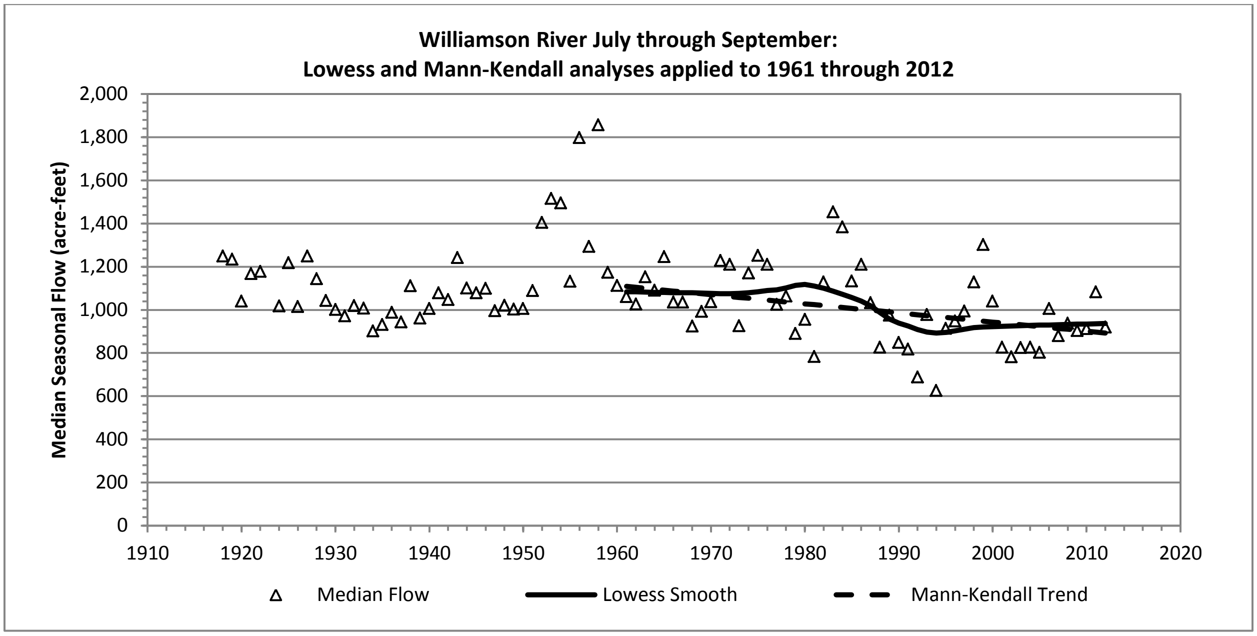
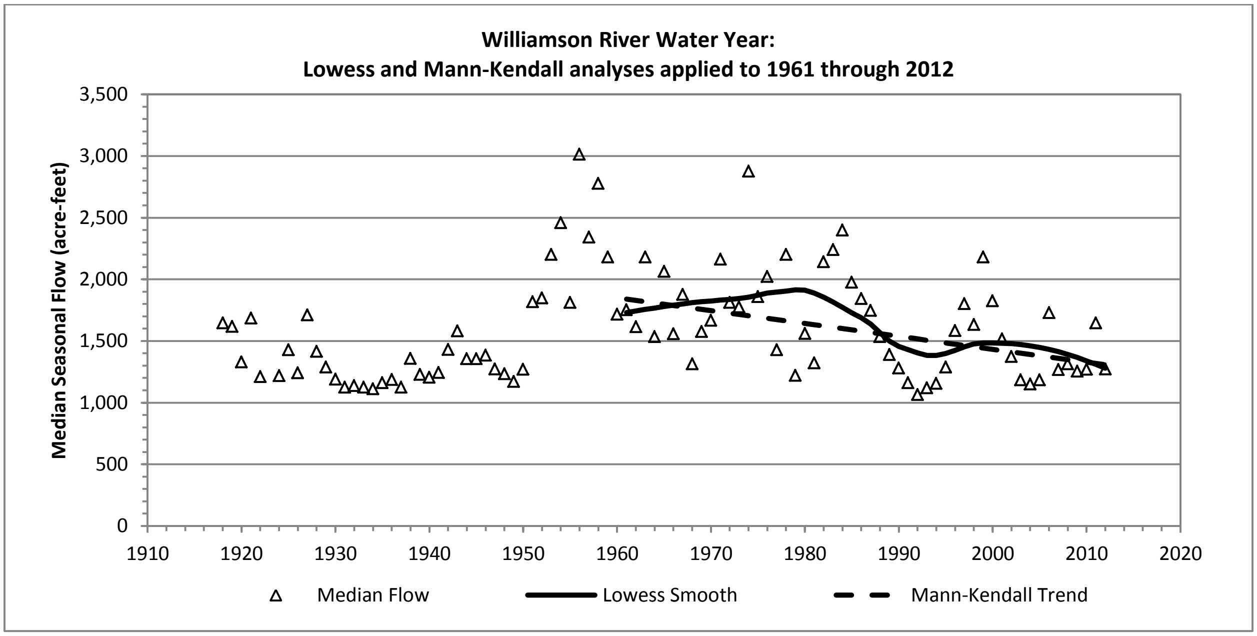
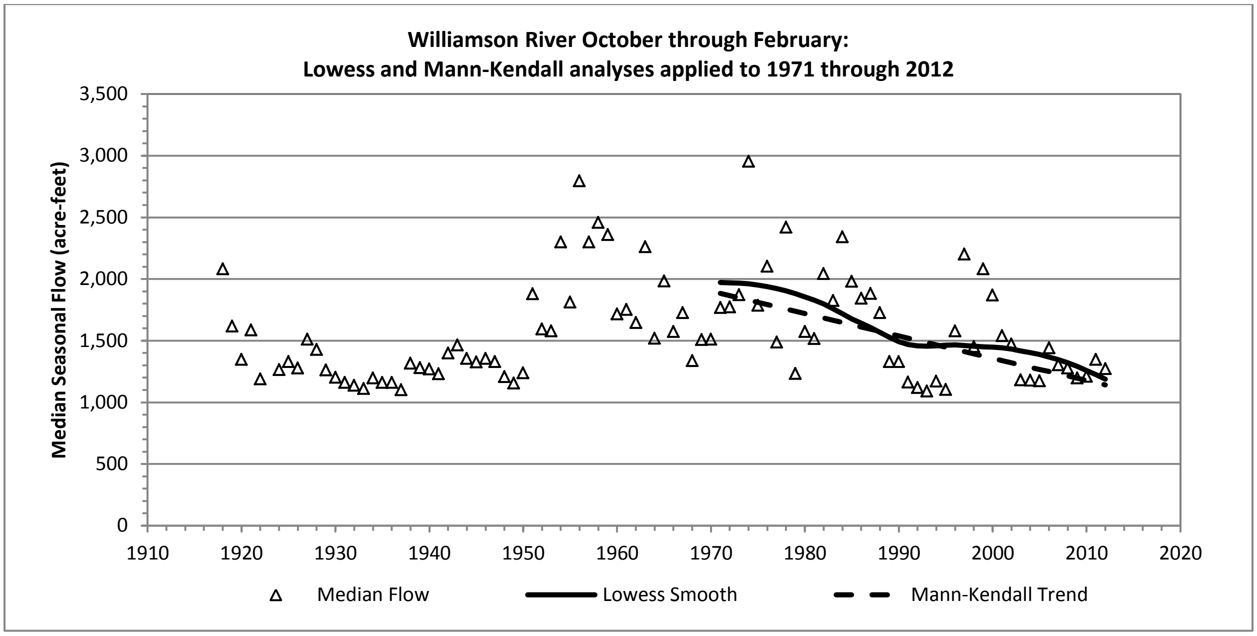
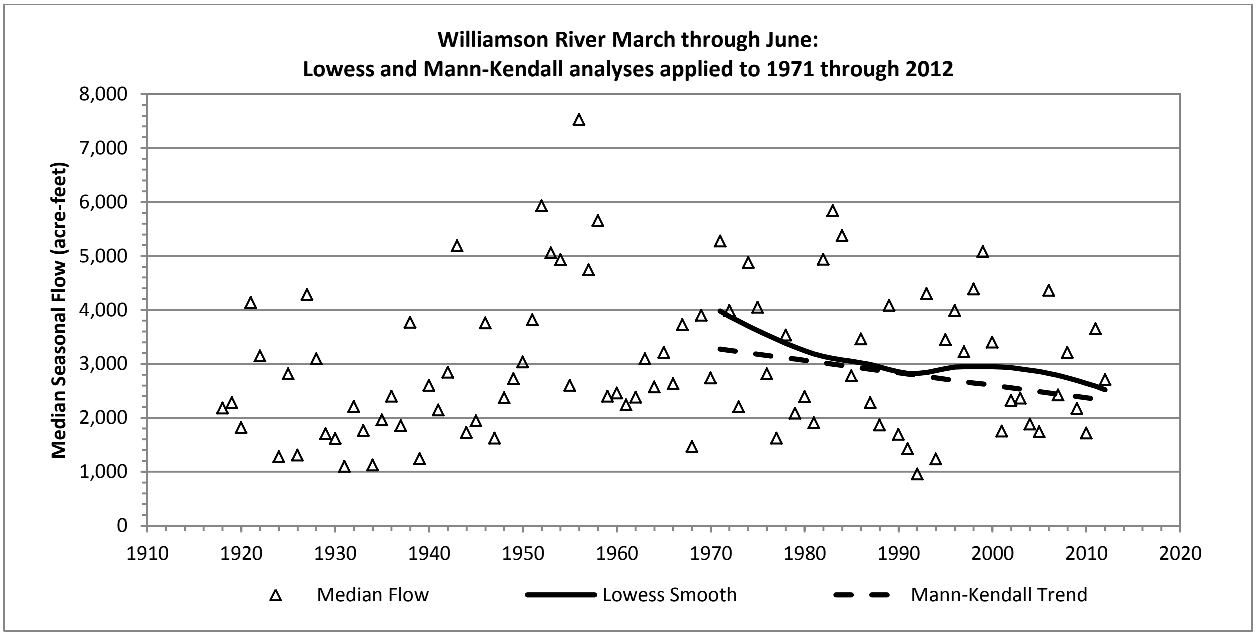
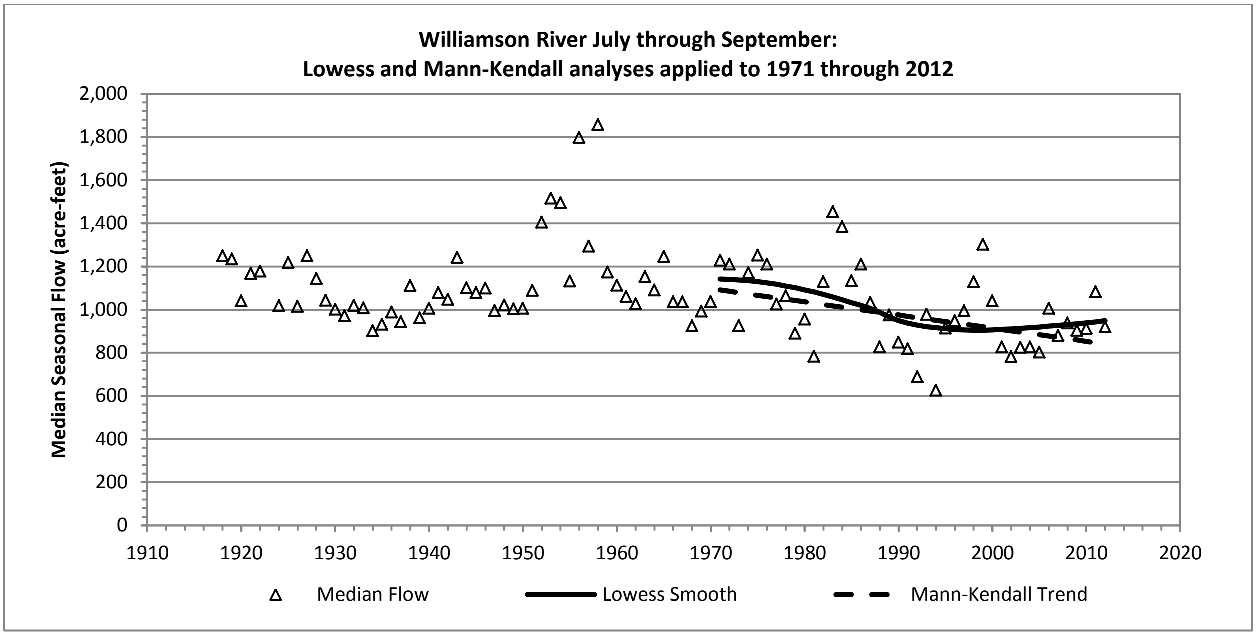
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1961 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

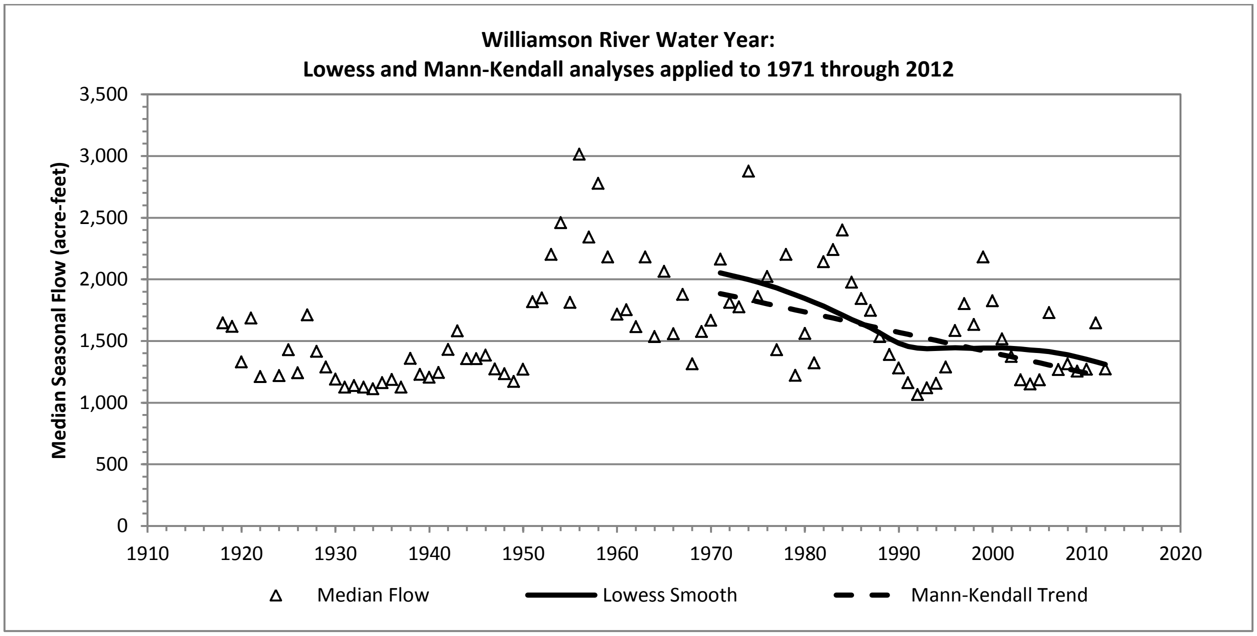

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1961 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend


Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

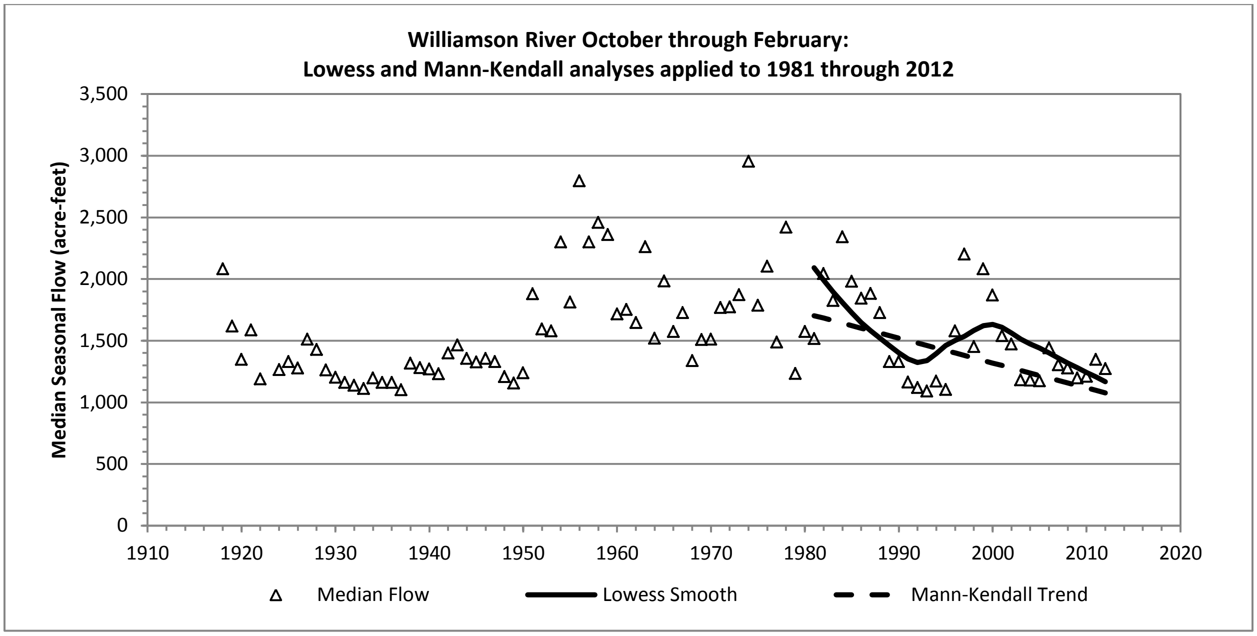

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

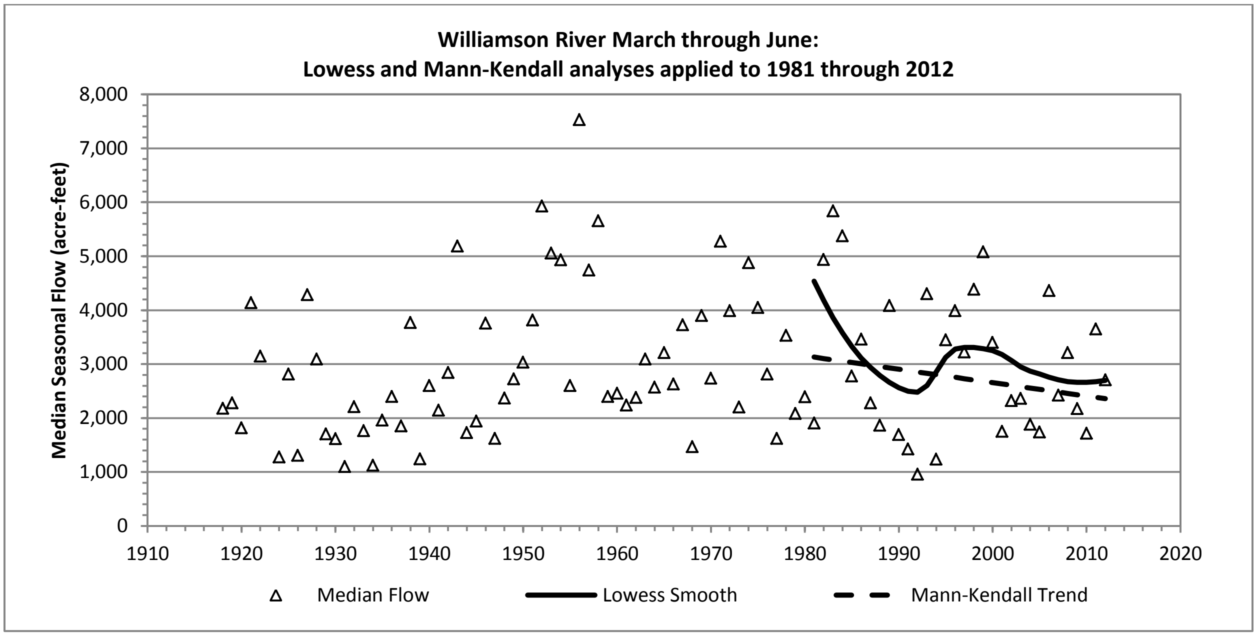


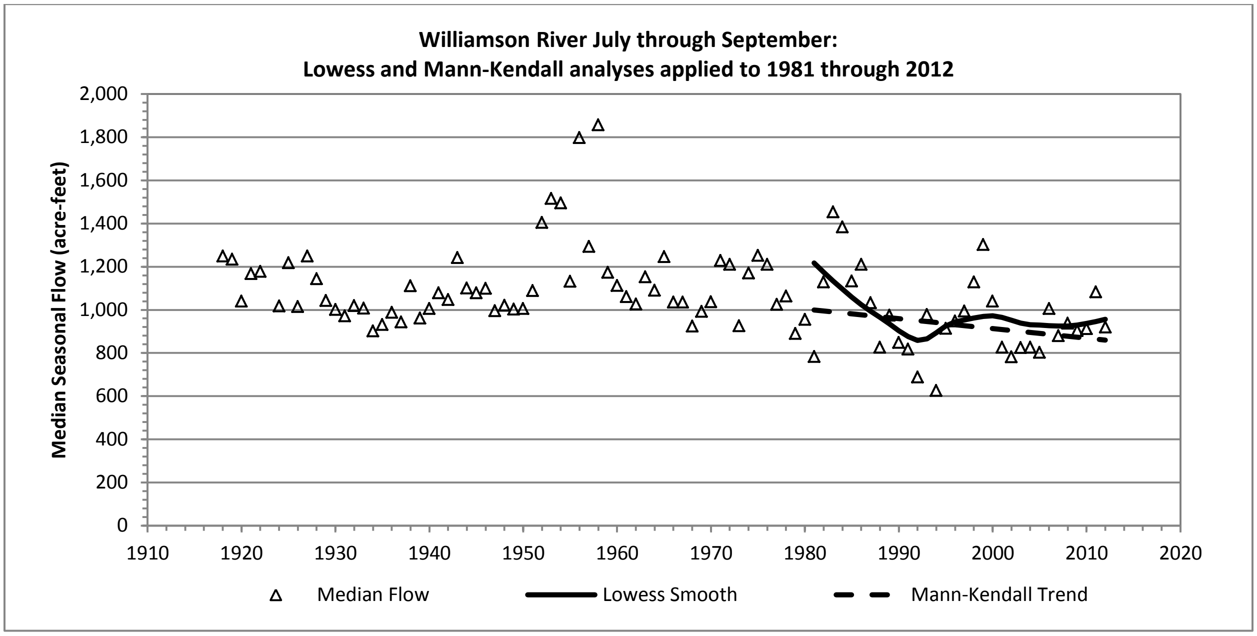
Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

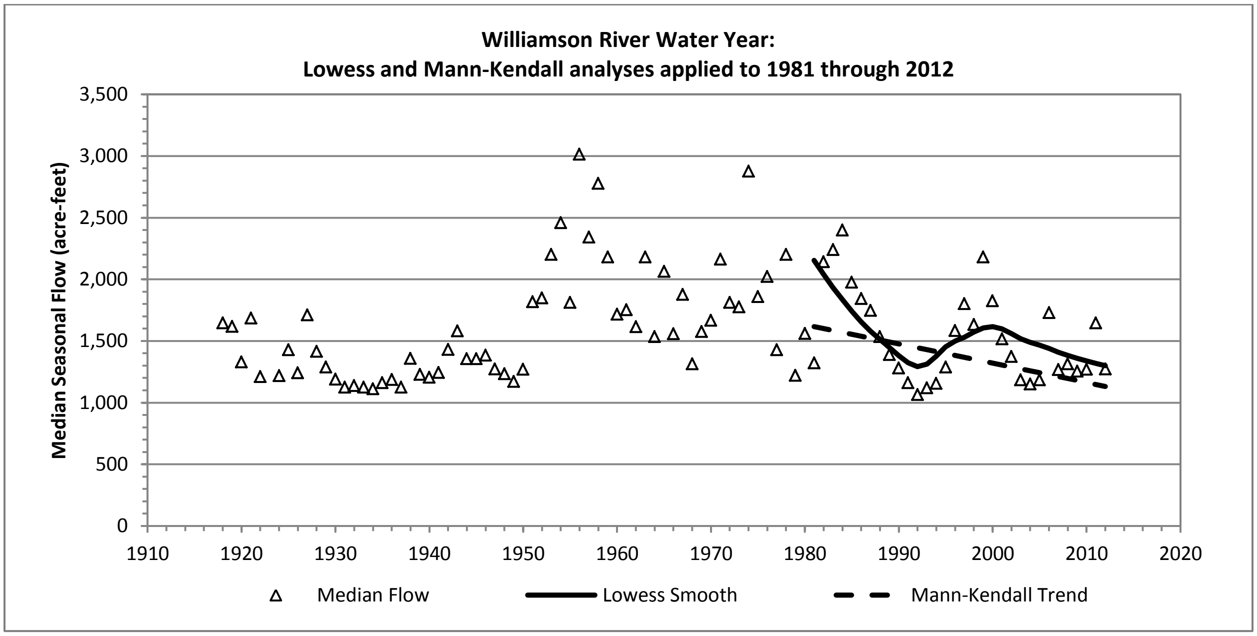


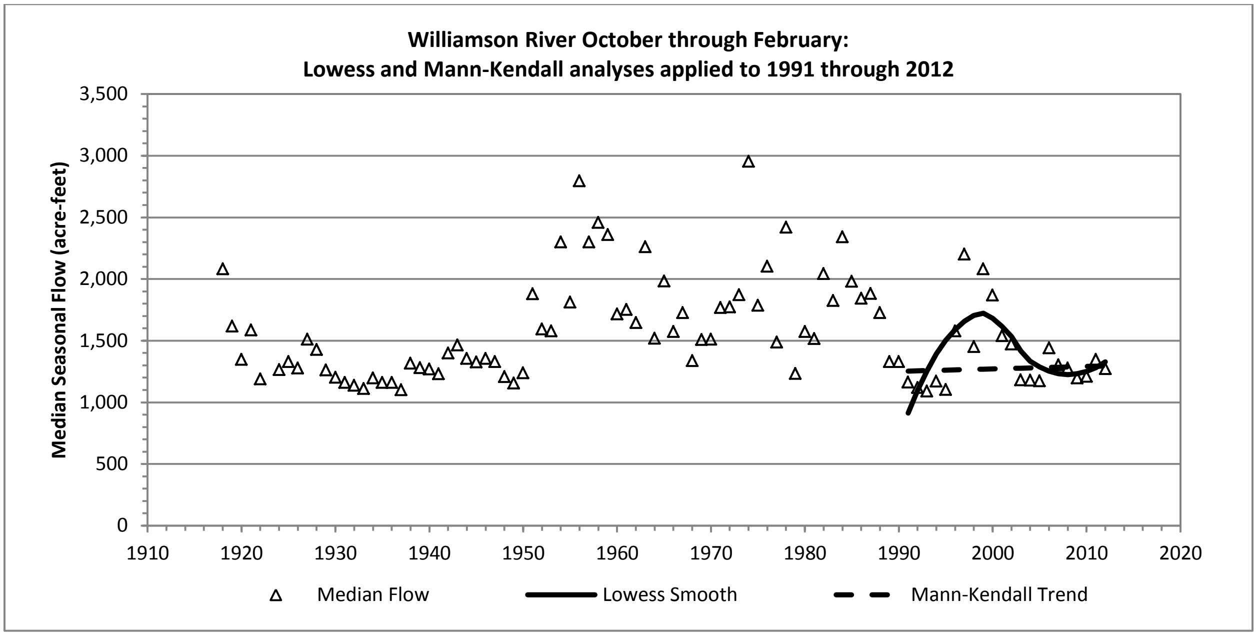
Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1971 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

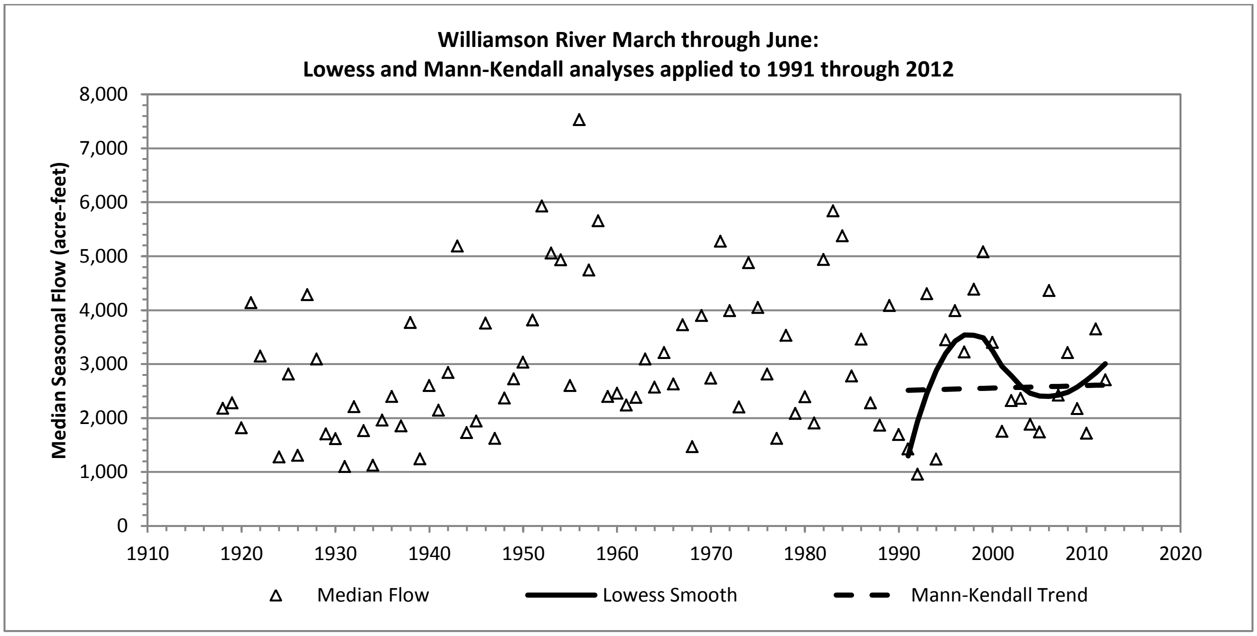

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

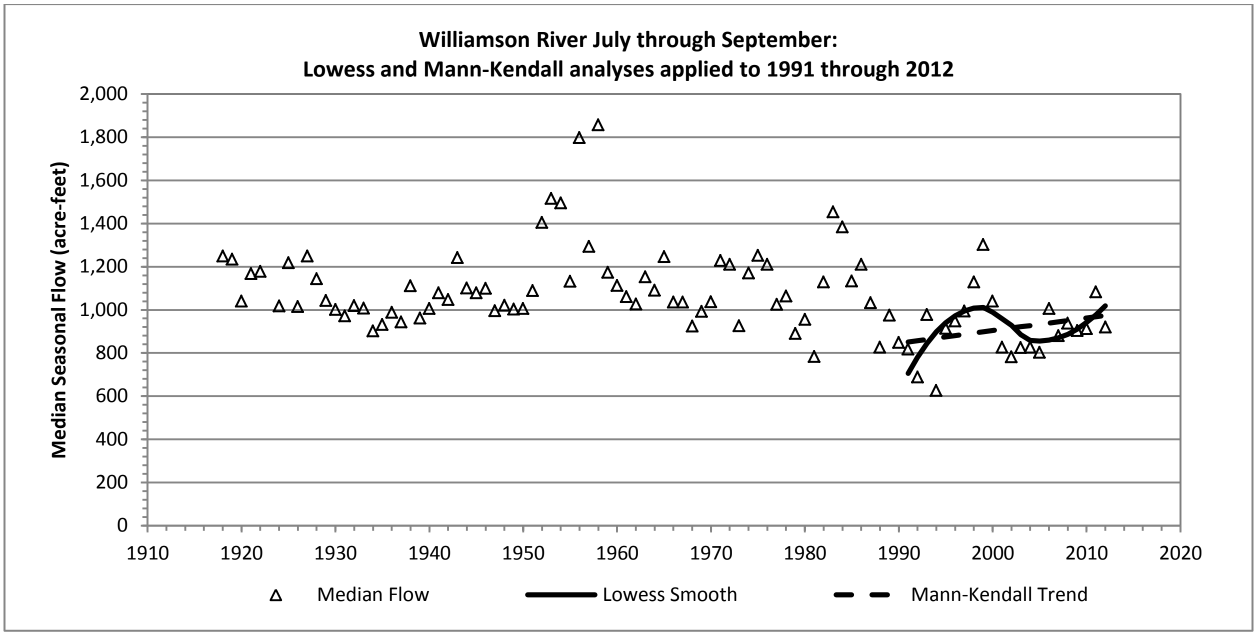

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

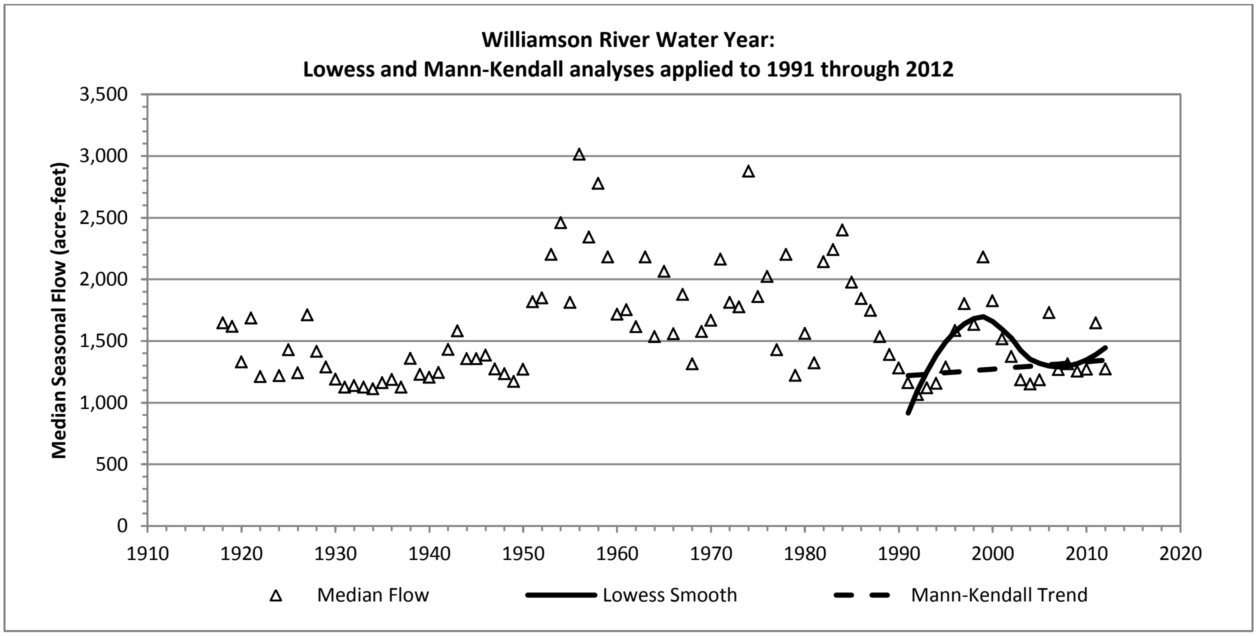

Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

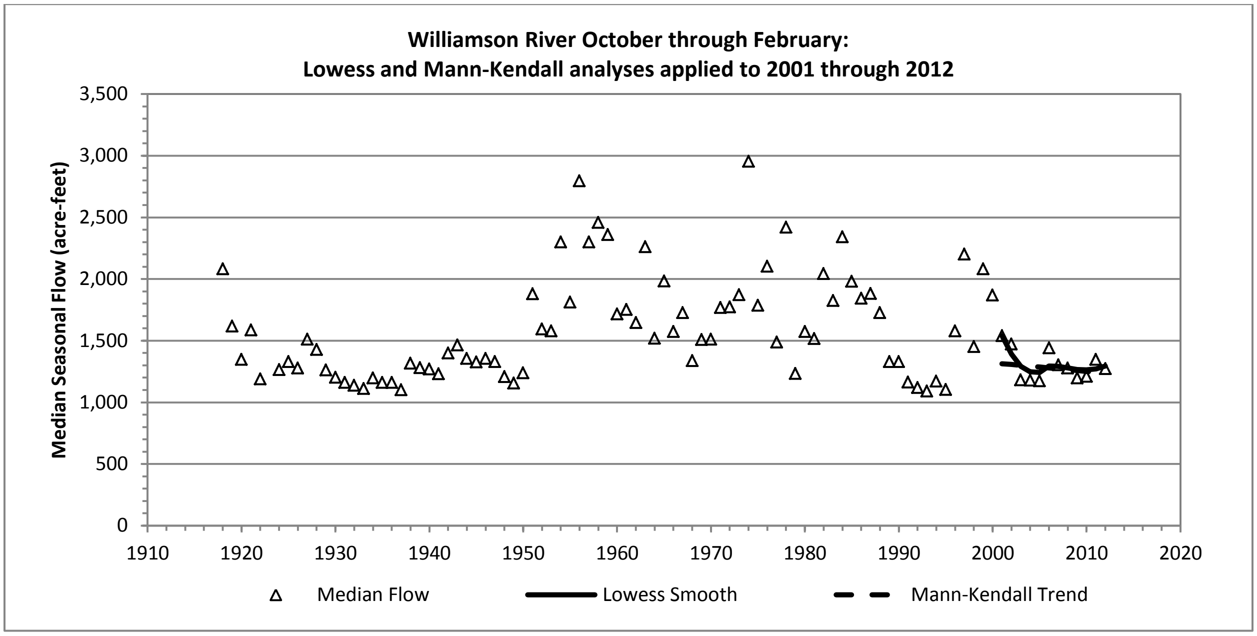

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

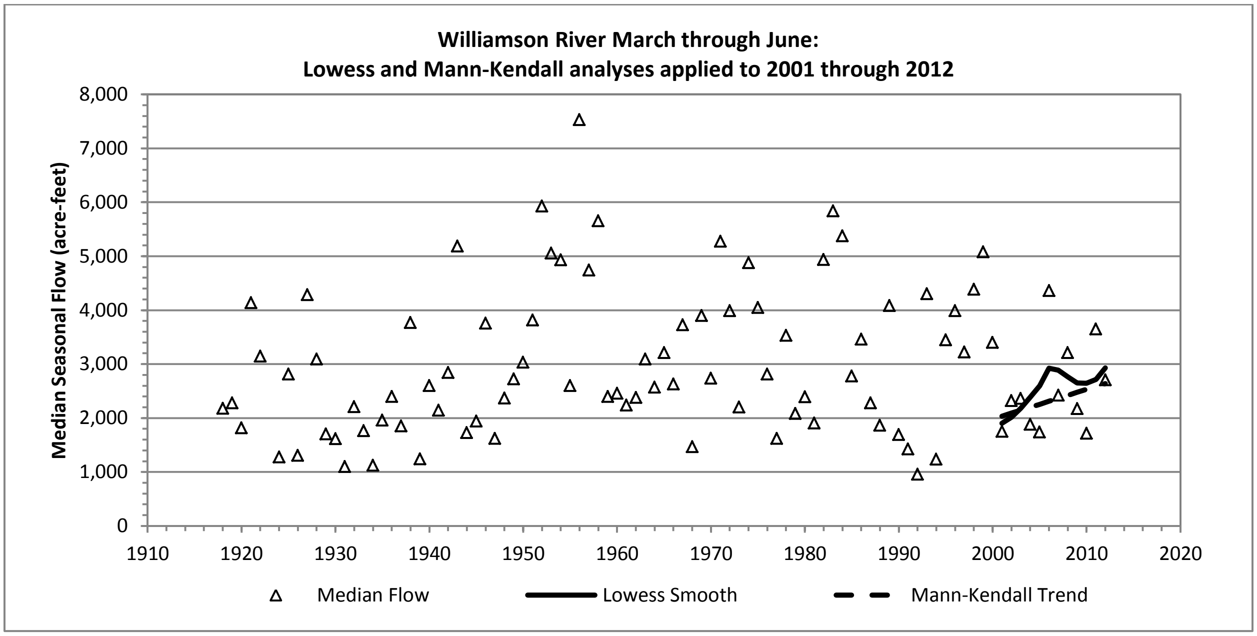

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

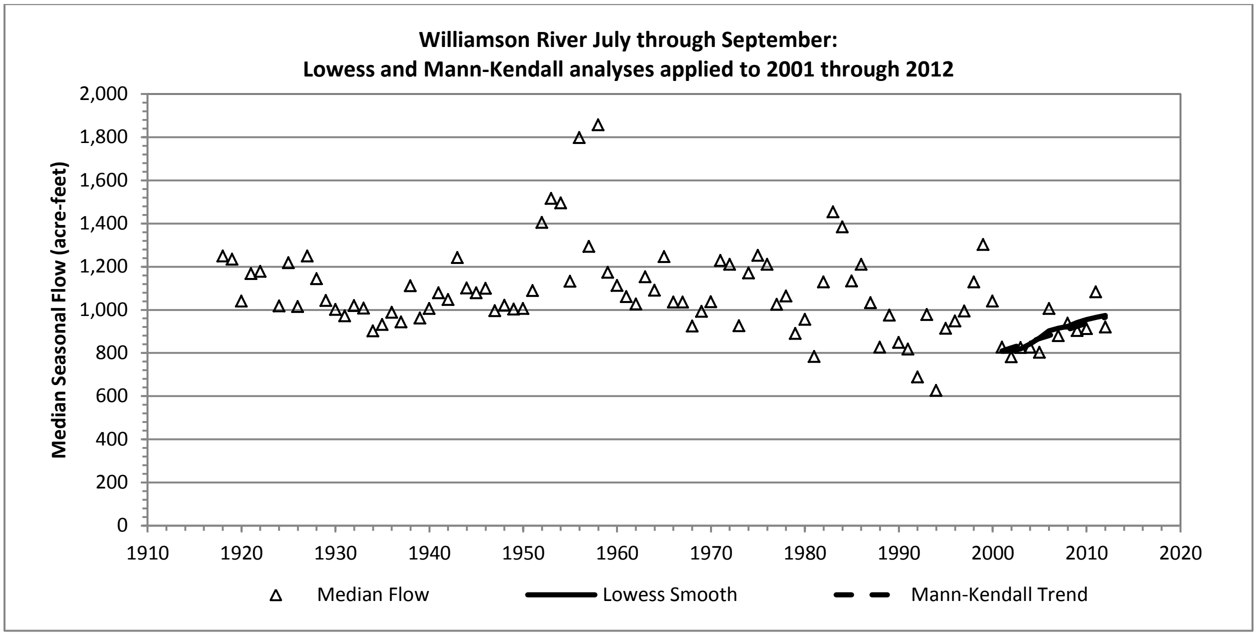

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

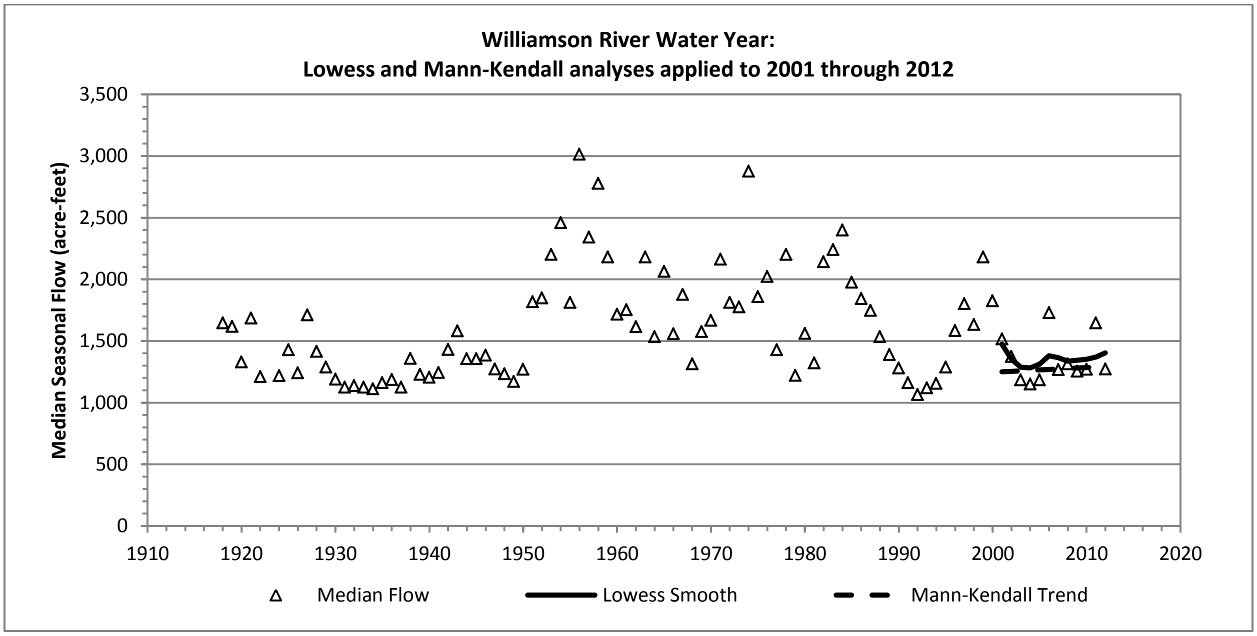

Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

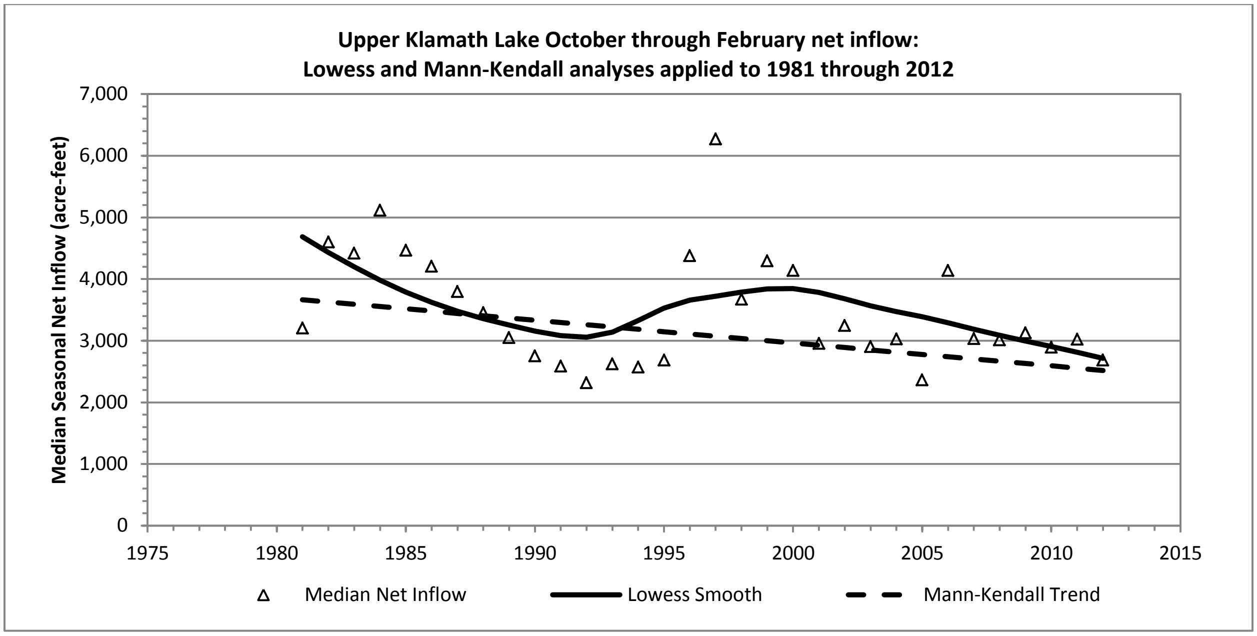

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

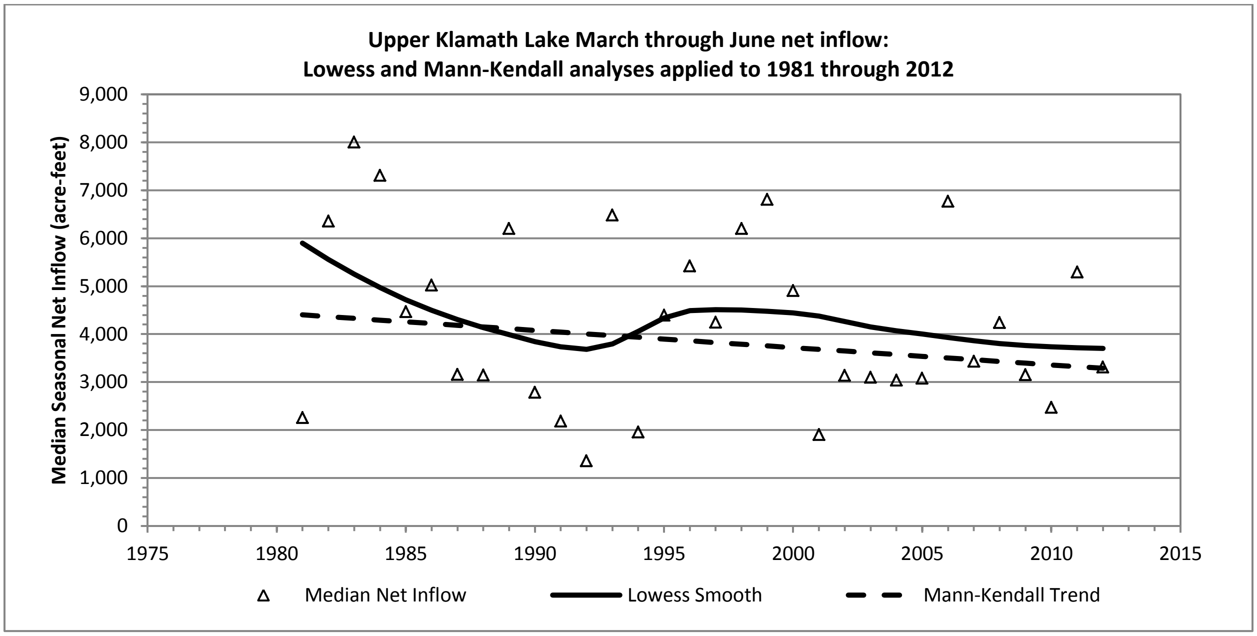

Williamson River October through February:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

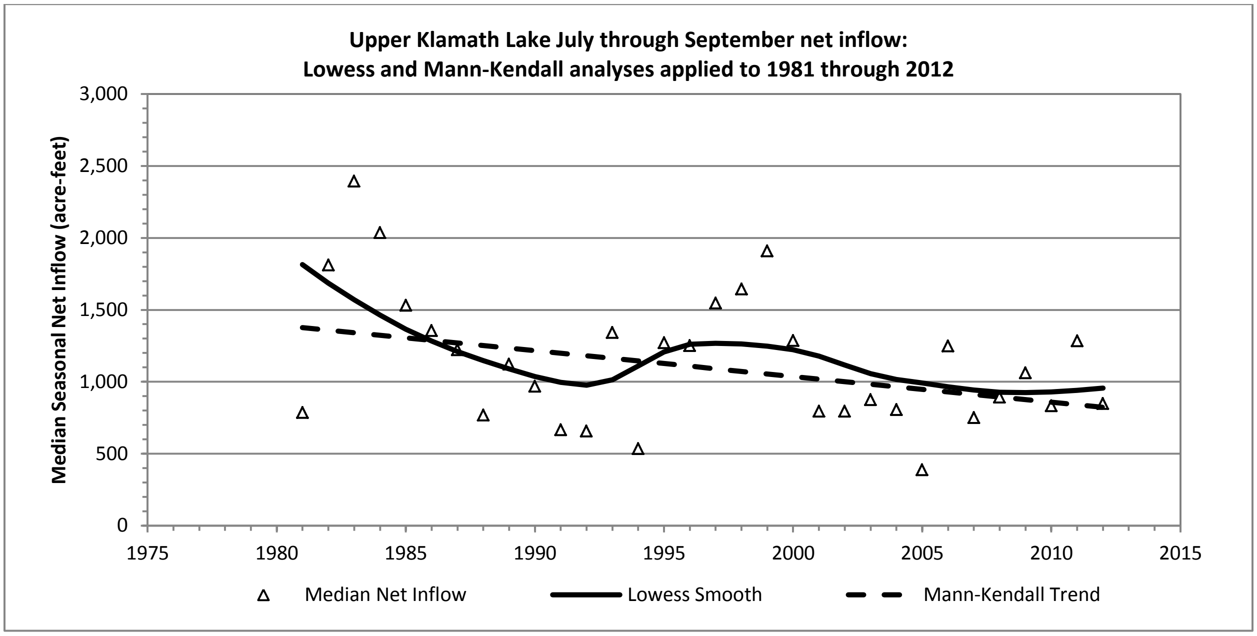

Williamson River March through June:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

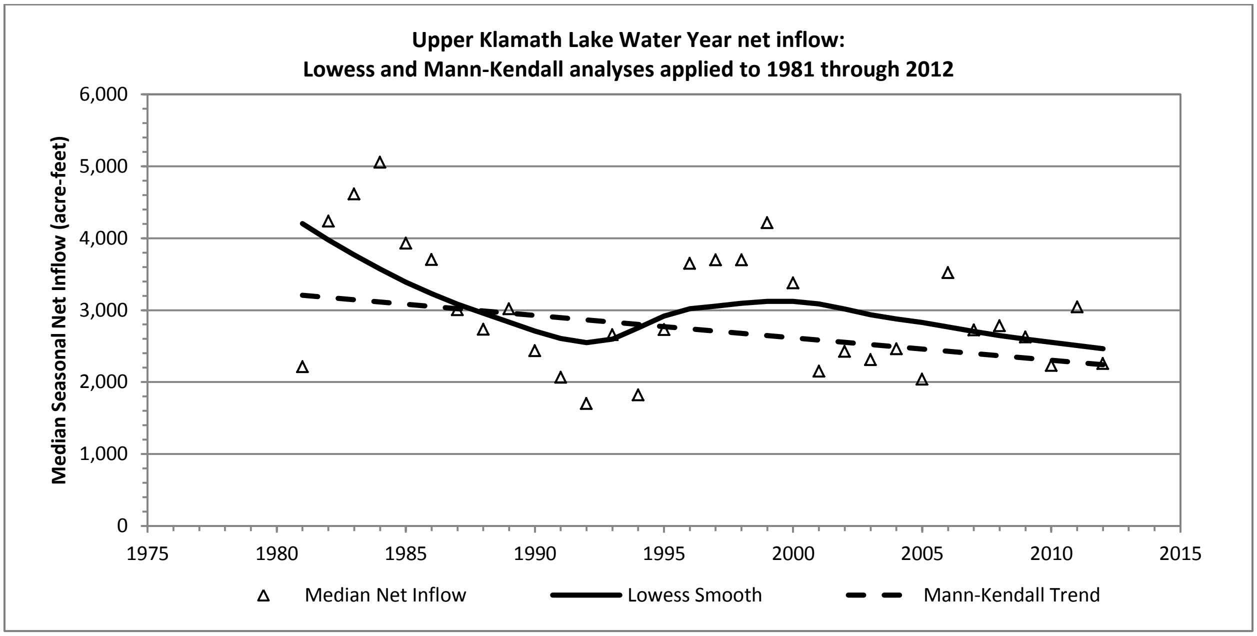

Williamson River July through September:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

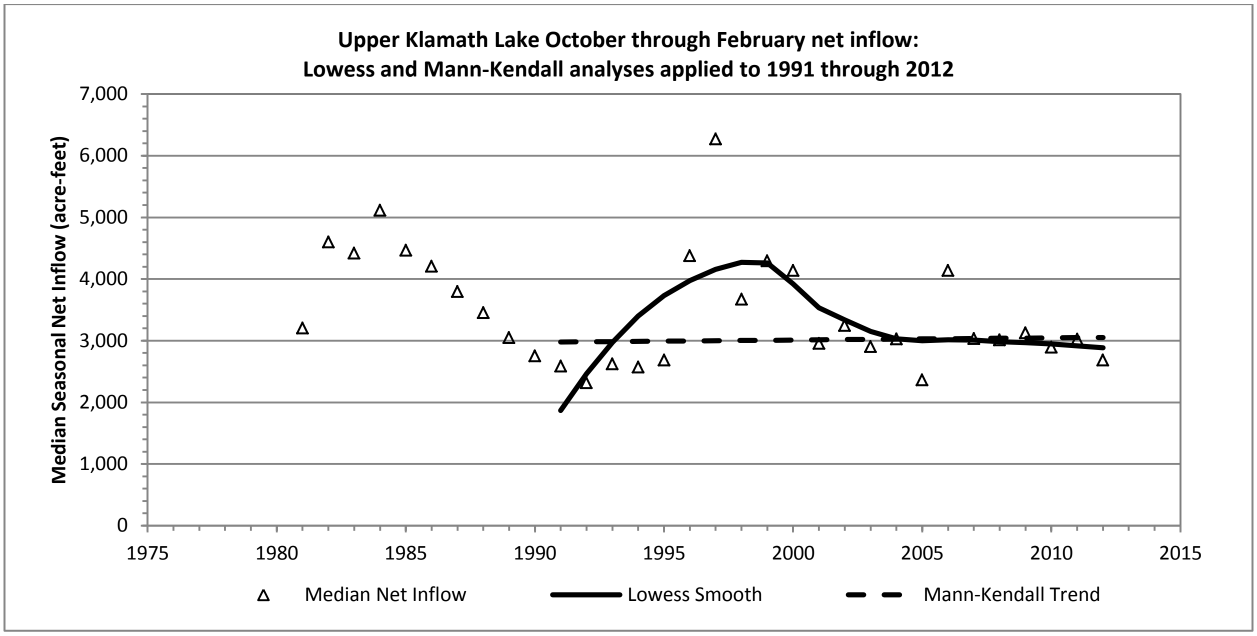

Williamson River Water Year:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Flow (acre-feet)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Median Flow
Lowess Smooth
Mann-Kendall Trend

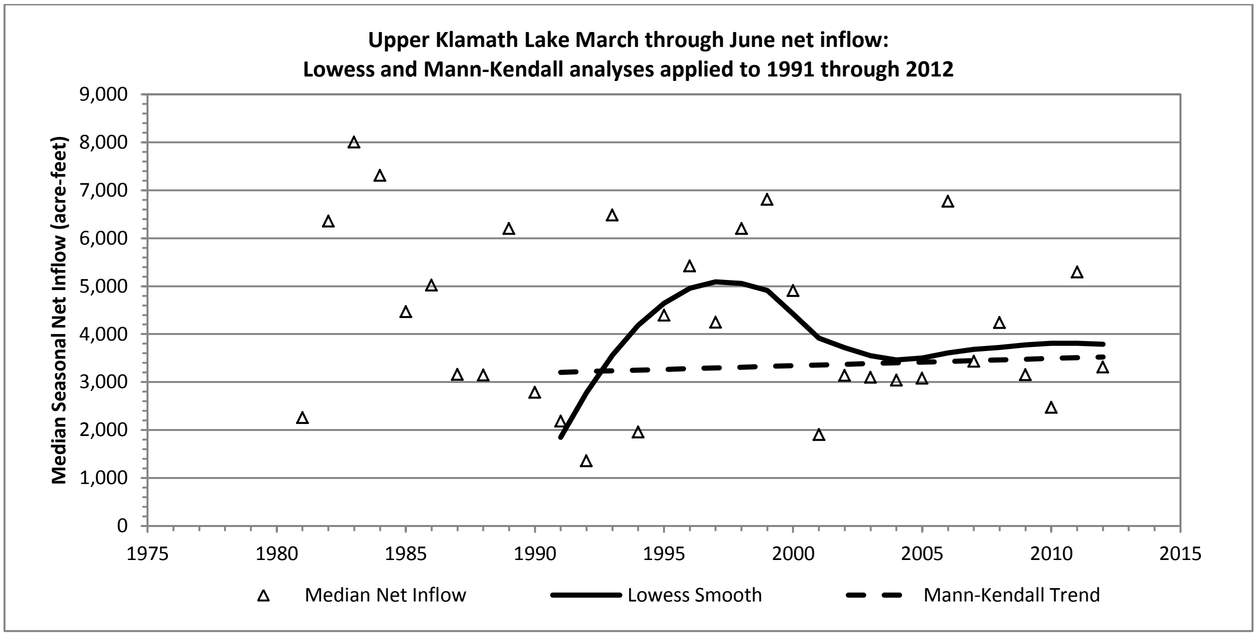

Upper Klamath Lake October through February net inflow:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Net Inflow (acre-feet)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

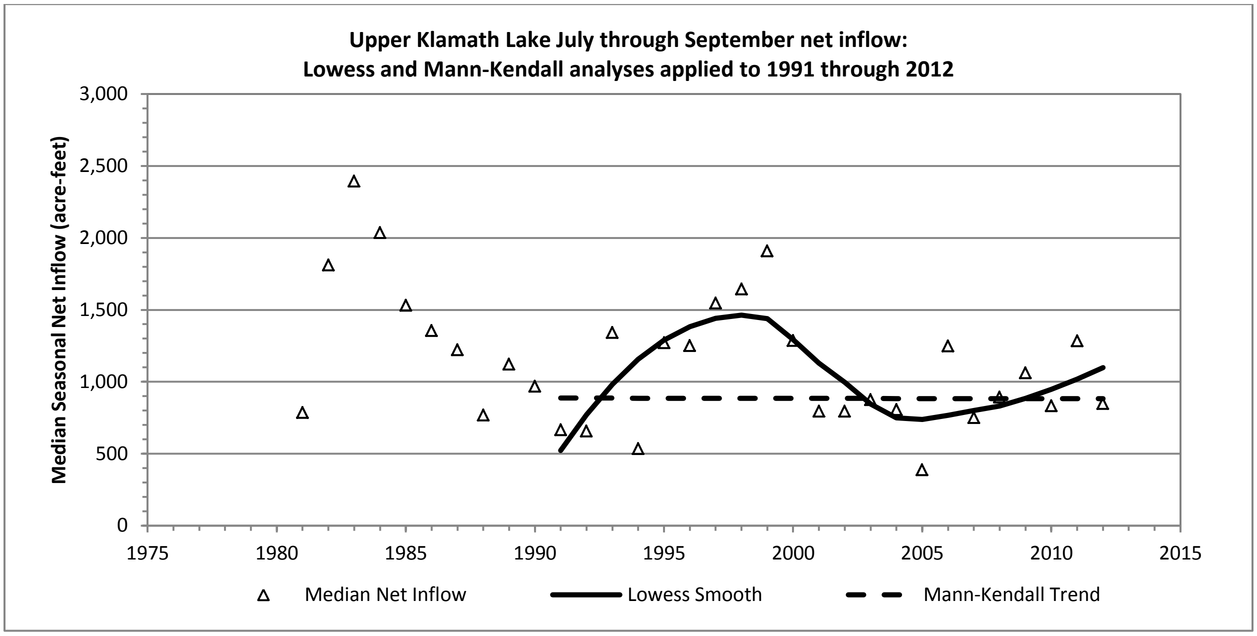

Upper Klamath Lake March through June net inflow:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Net Inflow (acre-feet)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

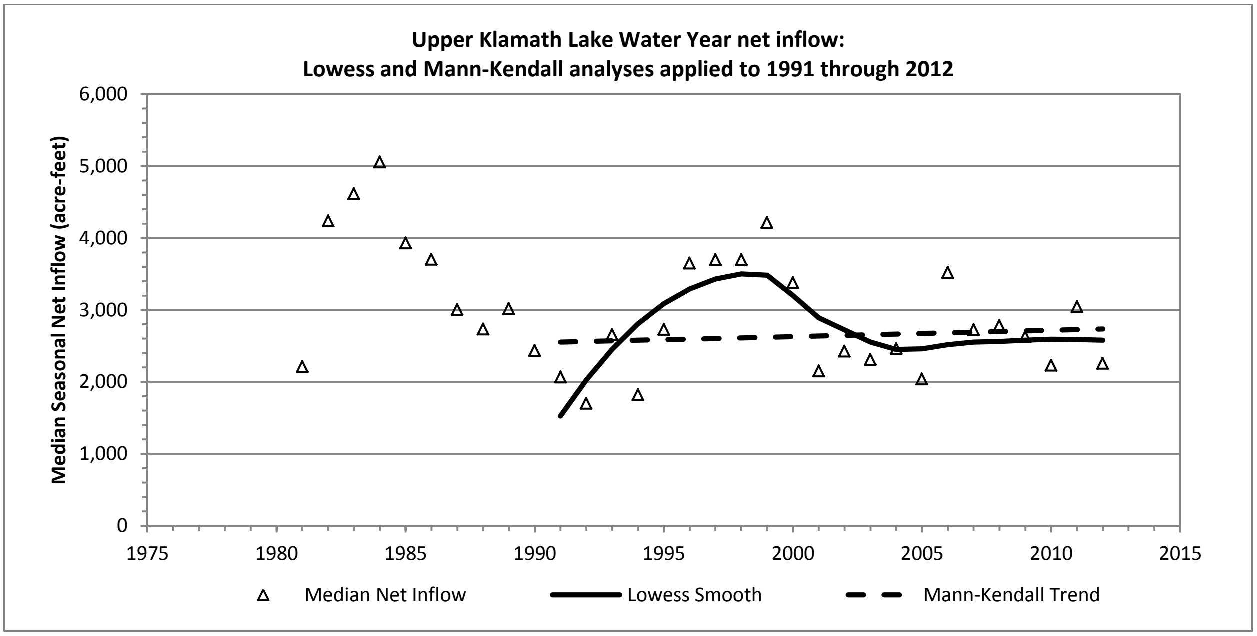

Upper Klamath Lake July through September net inflow:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Net Inflow (acre-feet)
3,000
2,500
2,000
1,500
1,000
500
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

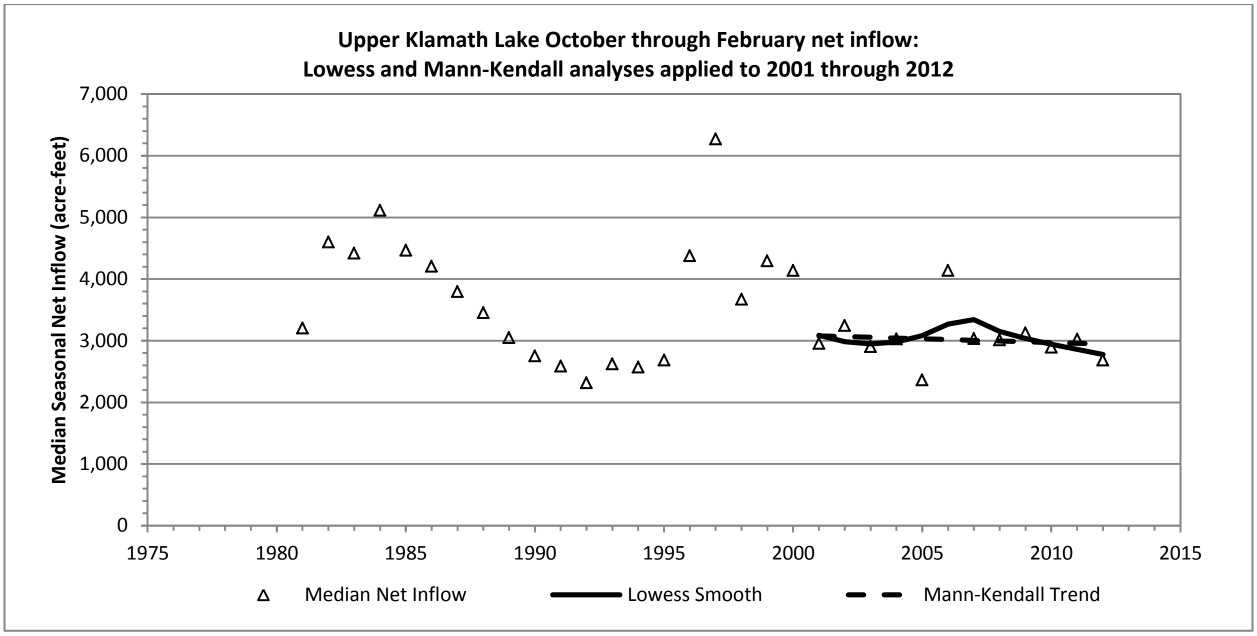

Upper Klamath Lake Water Year net inflow:
Lowess and Mann-Kendall analyses applied to 1981 through 2012
Median Seasonal Net Inflow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

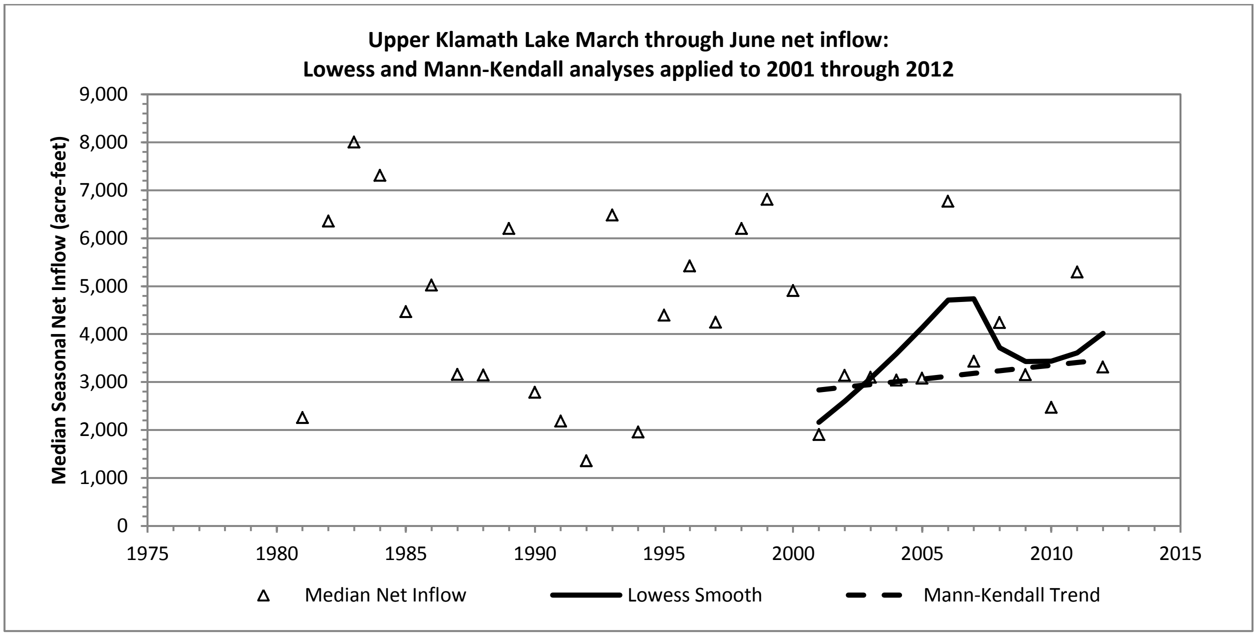

Upper Klamath Lake October through February net inflow:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Net Inflow (acre-feet)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

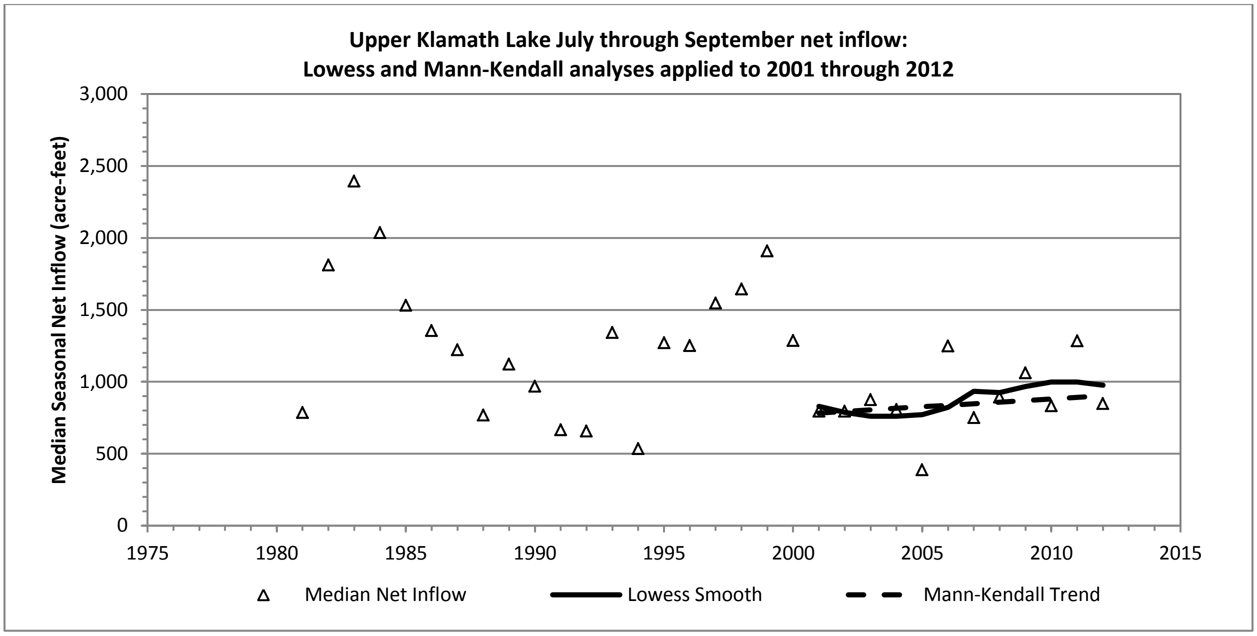

Upper Klamath Lake March through June net inflow:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Net Inflow (acre-feet)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

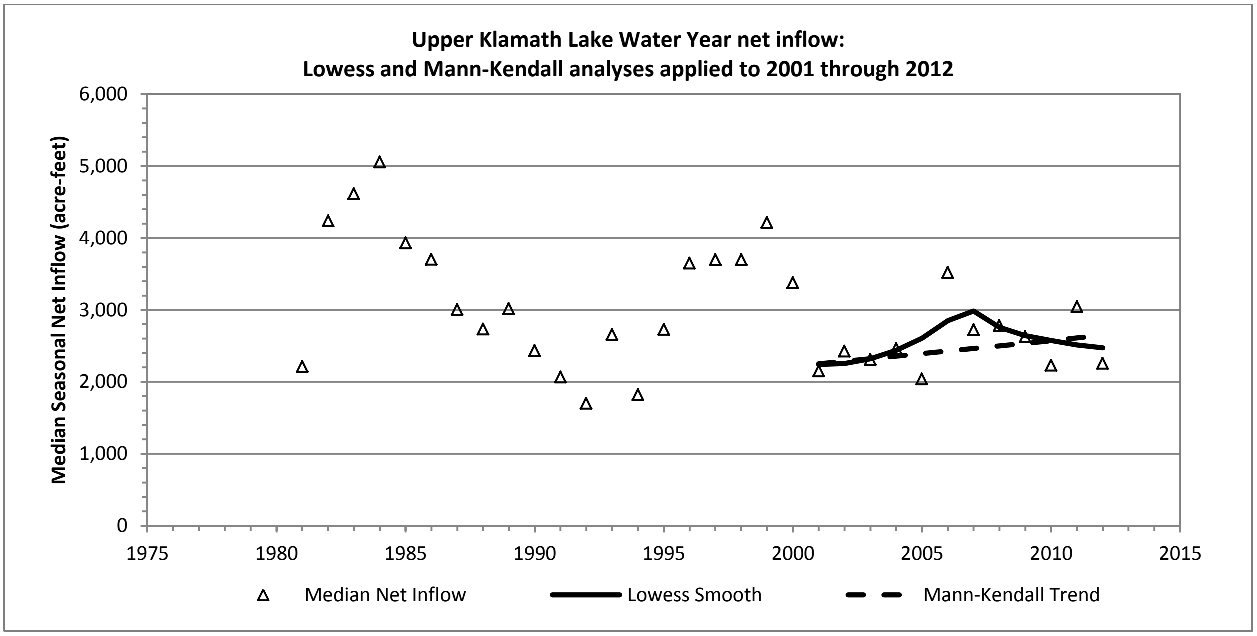

Upper Klamath Lake July through September net inflow:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Net Inflow (acre-feet)
3,000
2,500
2,000
1,500
1,000
500
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend


Upper Klamath Lake Water Year net inflow:
Lowess and Mann-Kendall analyses applied to 1991 through 2012
Median Seasonal Net Inflow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend


Upper Klamath Lake October through February net inflow:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Net Inflow (acre-feet)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

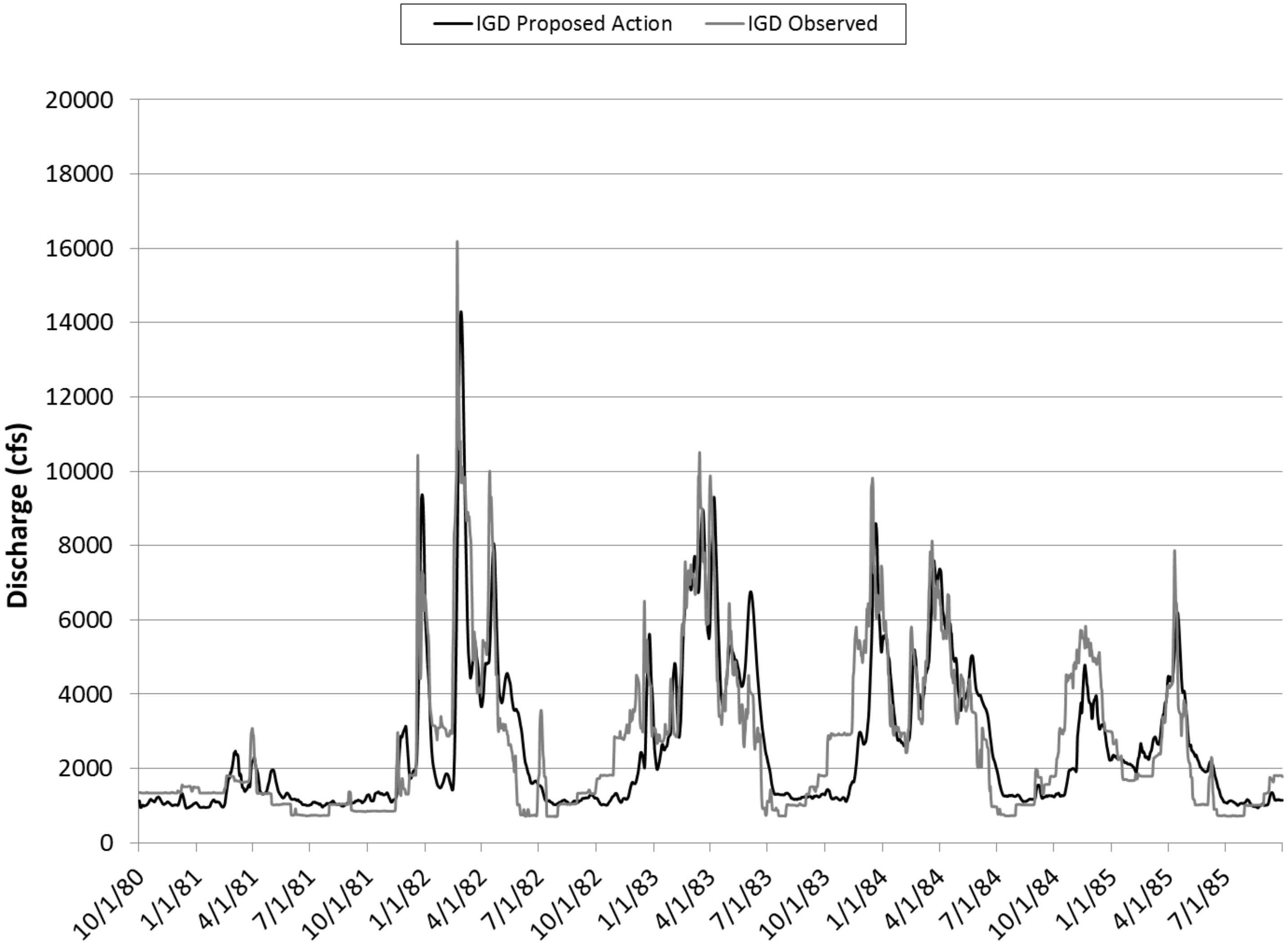

Upper Klamath Lake March through June net inflow:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Net Inflow (acre-feet)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend


Upper Klamath Lake July through September net inflow:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Net Inflow (acre-feet)
3,000
2,500
2,000
1,500
1,000
500
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

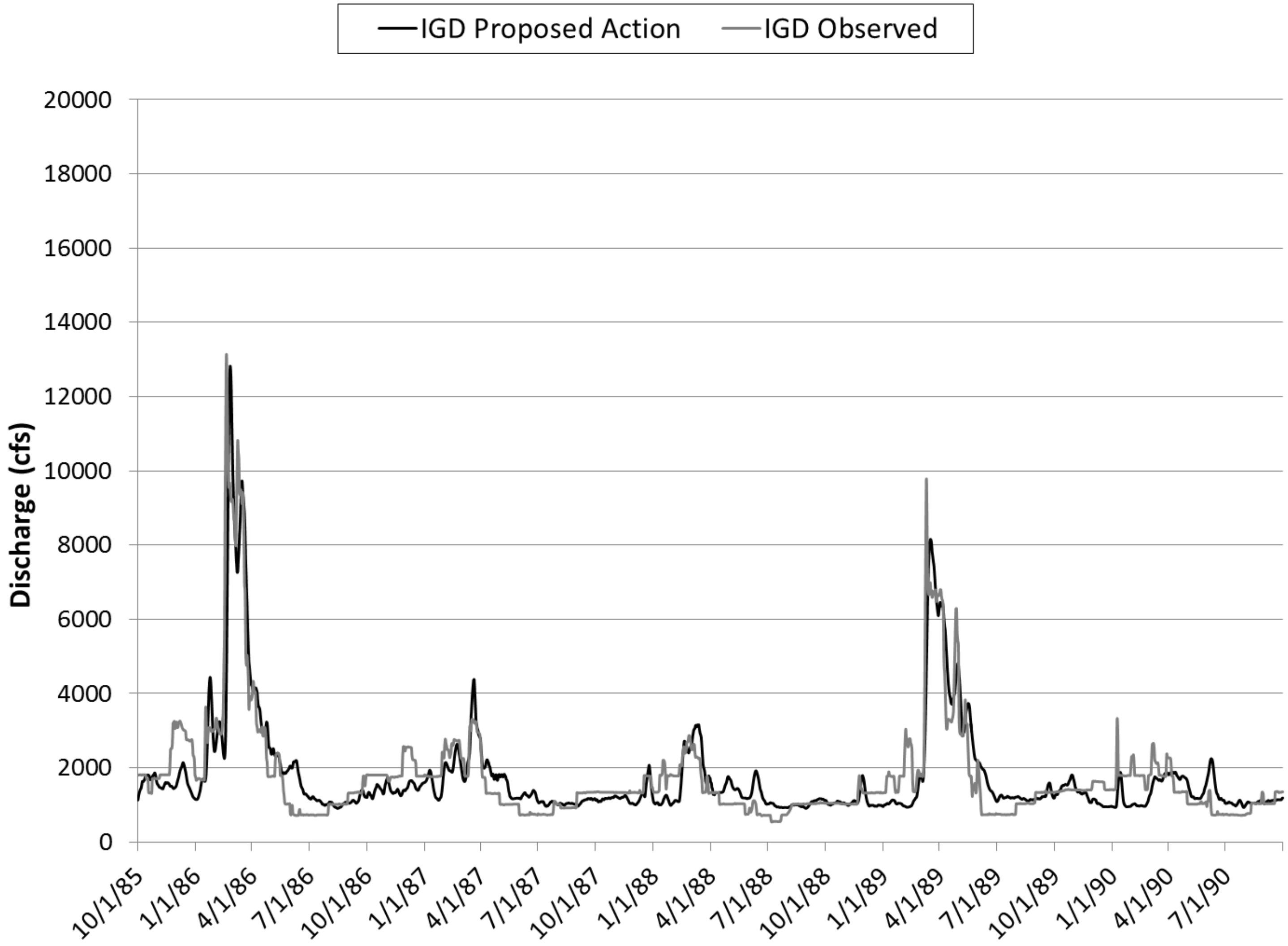

Upper Klamath Lake Water Year net inflow:
Lowess and Mann-Kendall analyses applied to 2001 through 2012
Median Seasonal Net Inflow (acre-feet)
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Median Net Inflow
Lowess Smooth
Mann-Kendall Trend

16.5 Appendix E: Observed and Modeled Flows

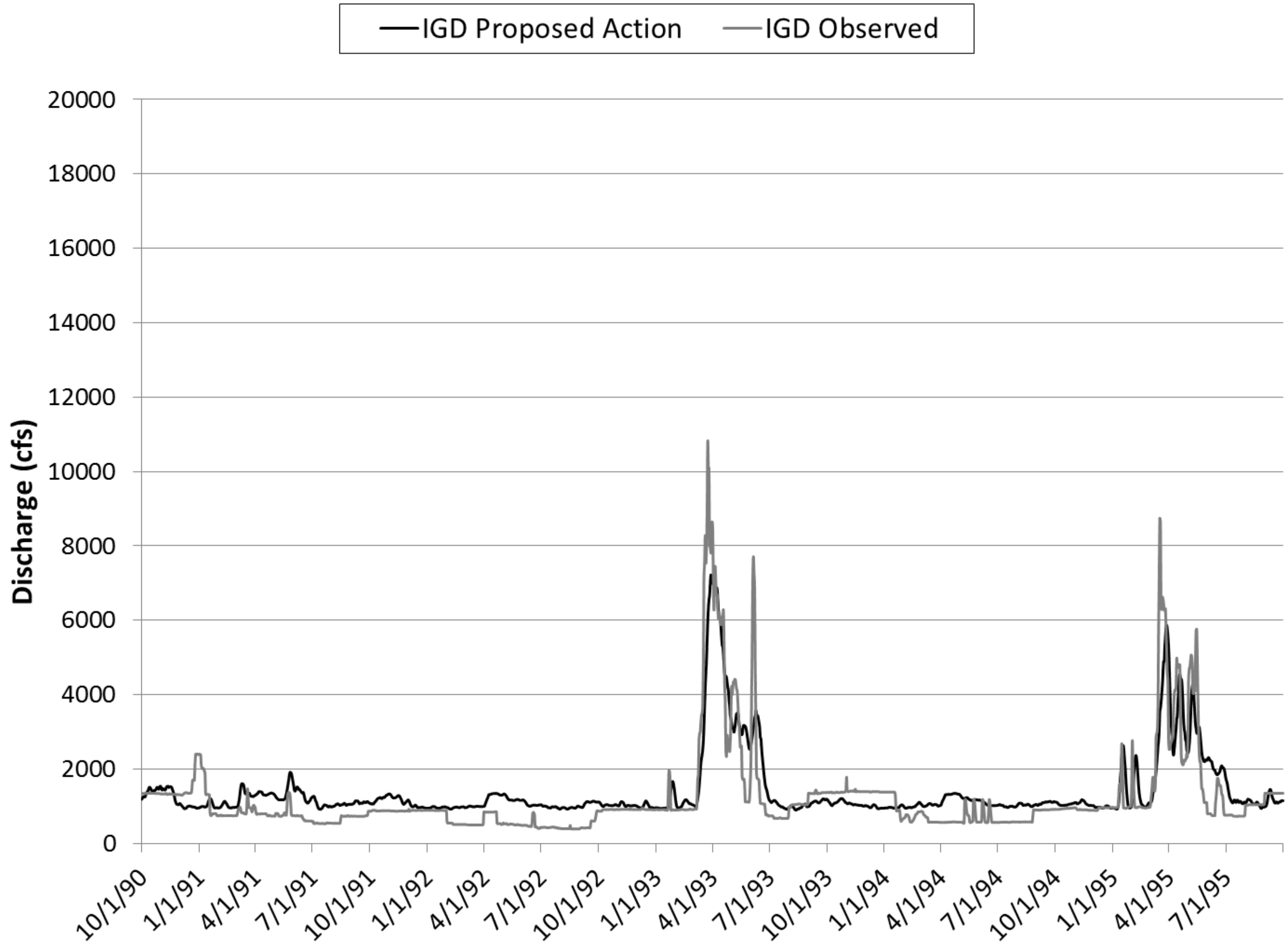
Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



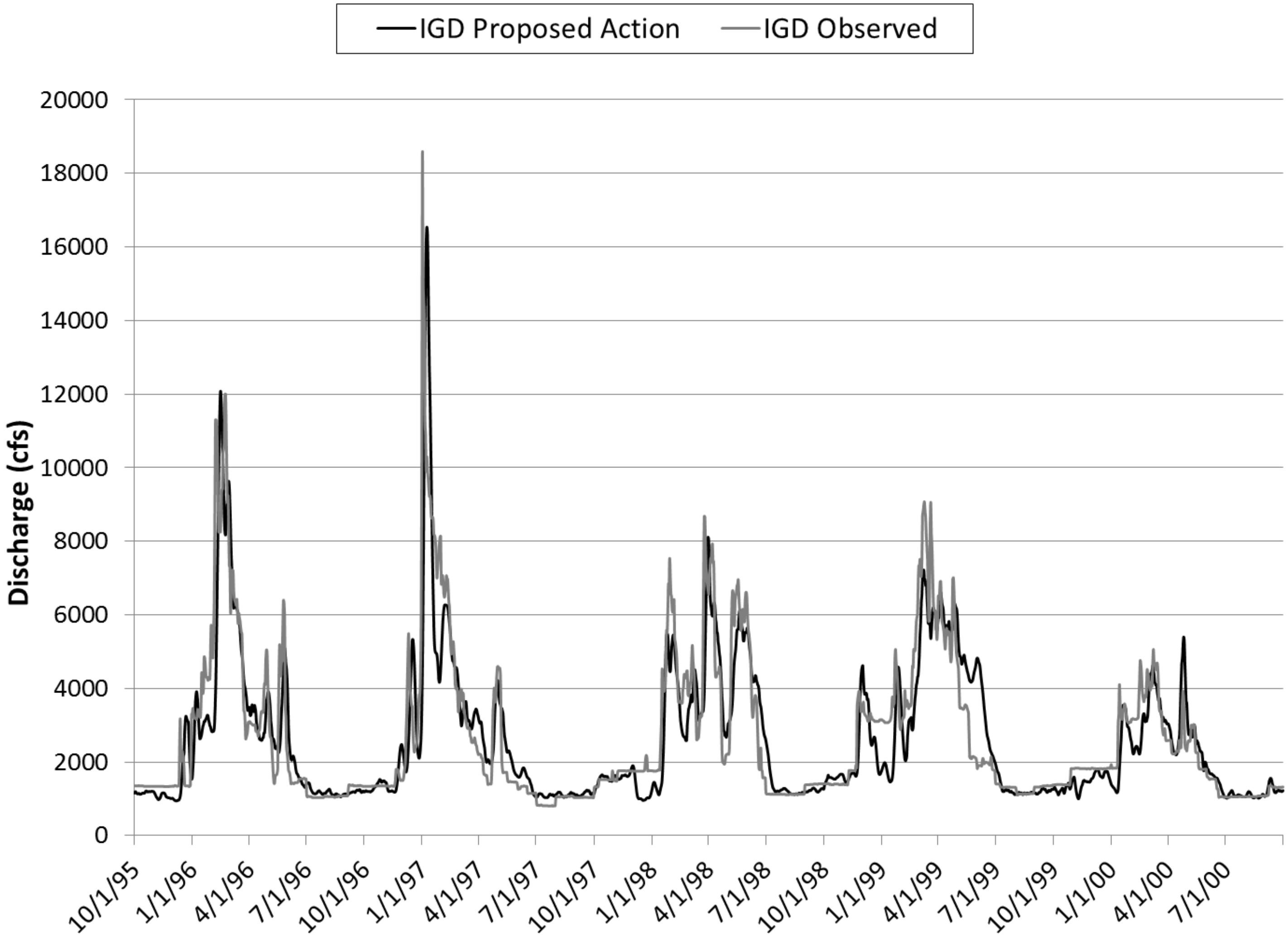
Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



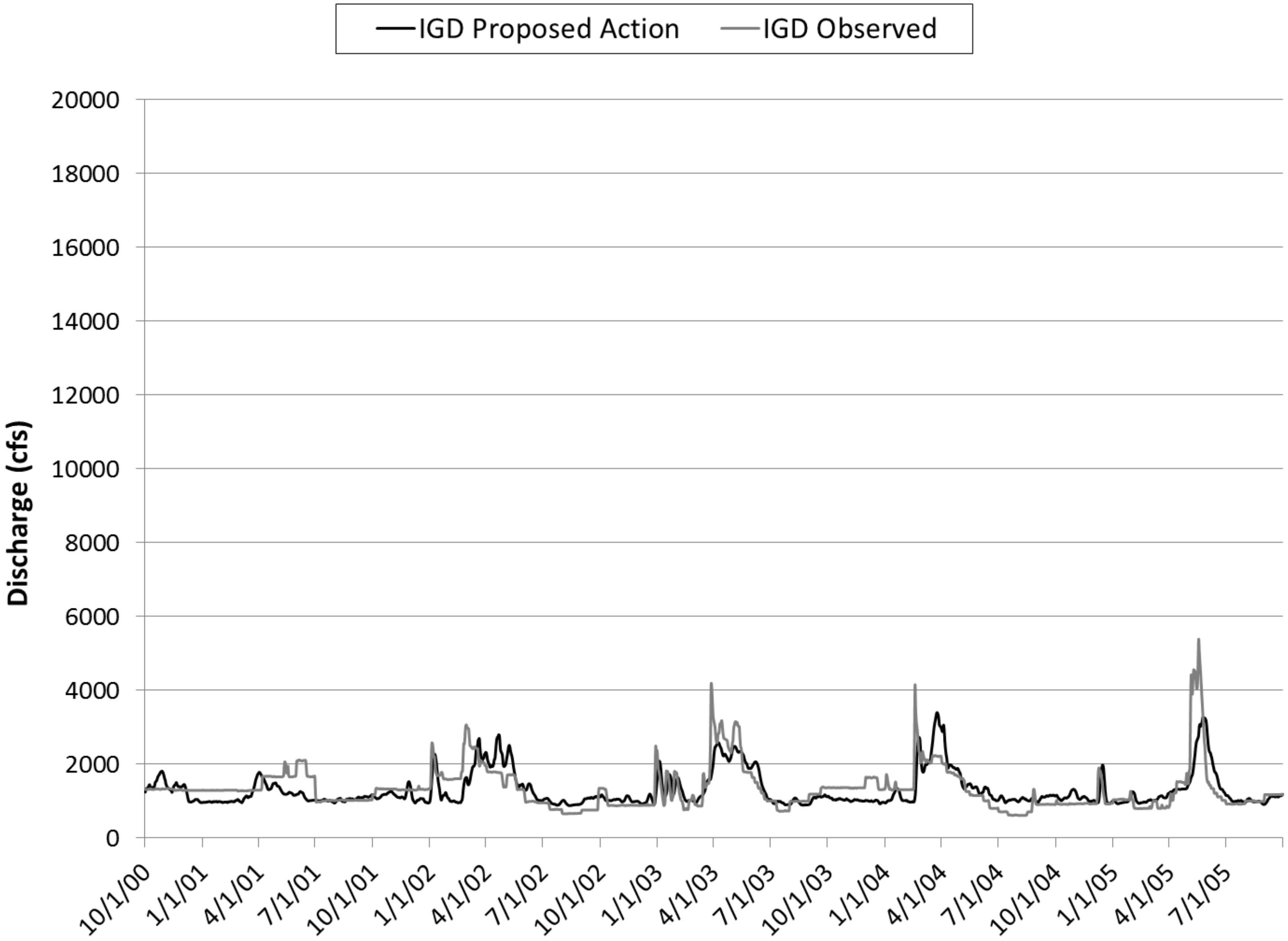
Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



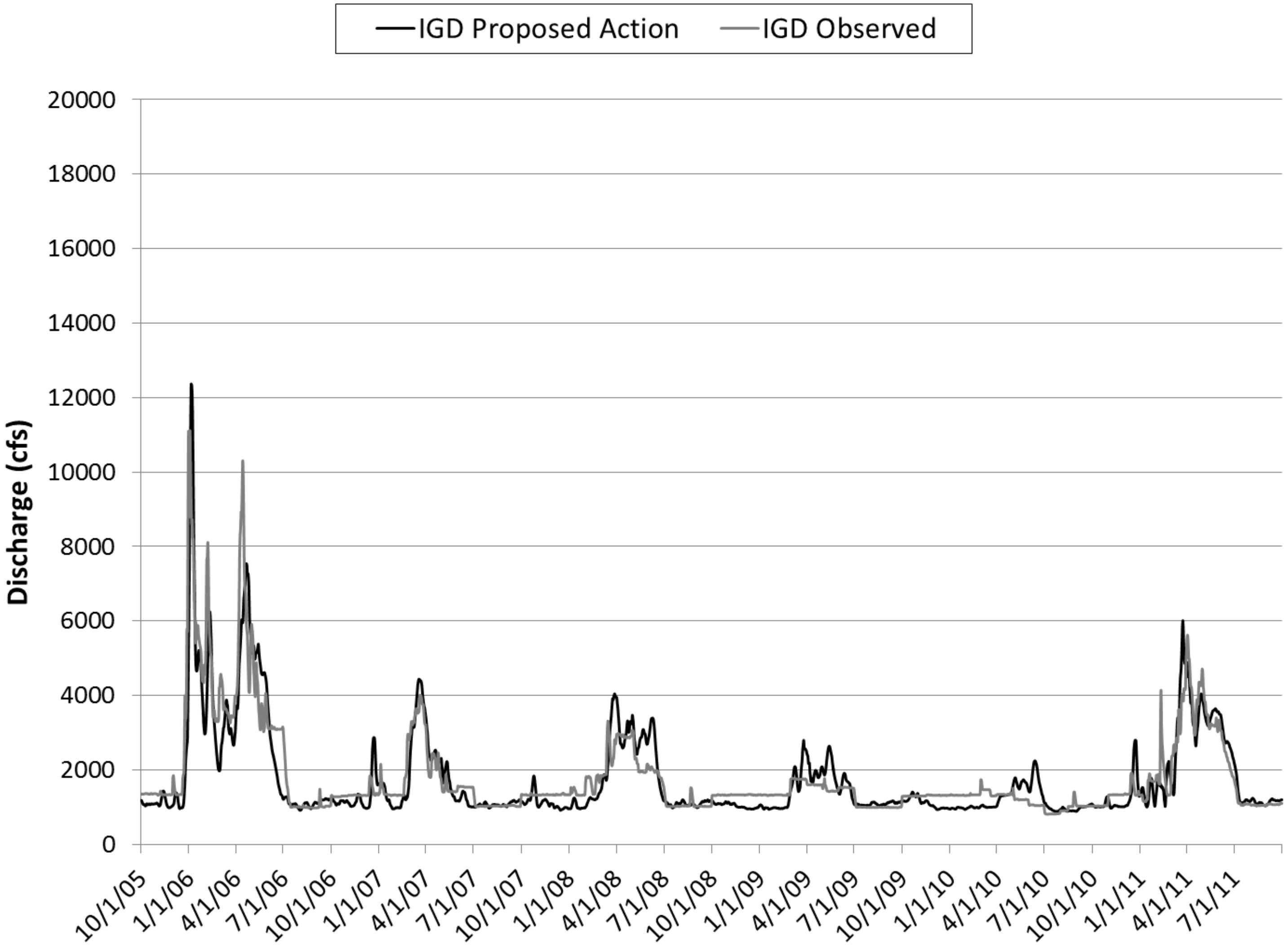
Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



Observed and modeled proposed action daily flows at Iron Gate Dam for the 1981-2011 period of record. Proposed action IGD daily flows are plotted on a 7-day moving average.



16.6 Appendix F: Analyzing the relationship of Iron Gate Dam releases on water temperature in the mainstem Klamath River during the spring

As described in this biological opinion (BiOp), NMFS has determined the Klamath Project (Project) will reduce Klamath River flows below Iron Gate Dam during the spring. The River Basin Model – 10 (RBM10) water temperature model was developed and calibrated for use on the Klamath River by Perry et al. (2011) to help inform the Secretary of the Interior on the likely changes to water temperatures that would be anticipated to occur should the four PacifiCorp hydroelectric dams on the mainstem Klamath River be removed, as described under the Klamath Hydroelectric Settlement Agreement (KHSA), and under instream flow management conditions described in the Klamath Basin Restoration Agreement (KBRA). Perry et al. (2011) simulated water temperatures over a period of 50 years using atmospheric and hydrologic data observed in the Klamath Basin from 1961 through 2009 to project potential conditions 50 years into the future from 2012 through 2061. This scenario is commonly referred to as the "index sequential" simulation under the Secretarial Determination process to evaluate the potential impacts and benefits that may occur under conditions described in the KHSA and KBRA. Future hydrologic conditions simulated were based on flows described under NMFS's 2010 BiOp (NMFS 2010) and the KBRA (available at Klamathrestoration.gov). Since these results provide paired results for differing flow releases from Iron Gate Dam, the RBM model was determined to be an appropriate tool to help describe potential influence of discharge below Iron Gate Dam on water temperatures during spring months, from March through June, when SONCC coho salmon fry, juveniles and smolts are known to be present using the mainstem.

The RBM10 simulation assumes that the four PacifiCorp Dams are removed in 2020. Therefore, for the purpose of evaluating the effect of flow on water temperature while dams are in place, the results of the first eight years (2012-2019) are applicable to the proposed action period. The RBM10 model results include mean daily water temperature (°C) and discharge (cfs) for several nodes along the mainstem Klamath River between river from river mile 253 and the estuary for each of two hydrologic conditions anticipated under the NMFS's 2010 BiOp and the KBRA. The paired results from these simulations allows for comparisons between the effects of different discharge levels, when they exist under these two scenarios, on water temperatures downstream of Iron Gate Dam.

Perry et al. (2011) found that the RBM10 generally performed well in predicting water temperatures in the Klamath River, predicted water temperatures tracked observed water temperatures well. The root mean square error for predicted water temperatures by reach ranged from 0.81 to 1.46 °C and mean absolute error among locations ranged from 0.62 to 1.15 °C (Perry et al. 2011).

For purposes of this analysis, only water temperature and discharge results for nodes present at Iron Gate Dam (RM 190), the Shasta River (RM 176) and the Scott River (RM 143) were used. To determine the change in water temperature (T-Delta) observed at each discharge, the mean daily water temperature predicted at the confluence of the Shasta River and the Scott River were each subtracted from the mean daily water temperature predicted at Iron Gate Dam. The rate in which mean daily water temperatures change by river mile was also calculated by dividing the change in water temperatures predicted by the number or river miles present between Iron Gate Dam and the confluence of the Shasta River and the Scott River, respectively. Daily values for each month were then averaged to derive mean monthly estimates for discharge, change in water temperature, and changes in water temperature rates estimated by the RBM-10 model for the Klamath River at the confluence of the Shasta River and Scott River, respectively.

Results and Summary

The change in mean monthly water temperature (T-Rate) with mean monthly discharge (cfs) for each month (March to June) and simulated year (2012 to 2019) is presented in Table 1. In general, higher discharges resulted in less warming of the river (lower temperature rates) downstream of Iron Gate Dam to the Shasta River (14 RMs below Iron Gate) and temperature change rates decreased as flows progressed downstream to the confluence of the Scott River (47 RMs below Iron Gate). The addition of cold snow melt runoff contributions from the Scott River, in combination with a decrease in the effects of the thermal mass in Iron Gate reservoir, are likely responsible for the decrease in the warming rates observed at this location. For example, simulation results for both May of 2013 and June of 2014 show that water temperature in the mainstem Klamath River between Iron Gate Dam and the confluence of the Shasta River were warming, and were then cooling (negative temperature rates) at the confluence of the Scott River (Table 1).

The total change in water temperature between Iron Gate Dam and the confluence of the Shasta River and Scott River is displayed in Table 2. The maximum change in the modeled monthly water temperature at the confluence of the Shasta River never exceeded 1.30 °C and only exceeded 1 °C for 9 of the 64 scenarios (14%) examined. The differences in water temperature between paired discharge model scenarios were always 0.5 °C or less, regardless of the magnitude in the difference between discharged simulated in each pair. The maximum change in simulated water temperatures at the confluence of the Scott River only exceeded 2 °C on one occasion and was generally less than 1.6 °C. Differences in water temperature between paired discharge scenarios never exceeded 0.6 °C, which indicates that discharge (within reasonable operating ranges) has little effect on water temperature and that effect diminishes further downstream as the influence of Iron Gate reservoir is diminished and ambient conditions begin to control water temperatures.

Although higher discharges generally resulted in less warming of water (lower rates of temperature change) downstream, the differences between the rates in which water temperatures changed by river mile relative to flow magnitude were found to be very small (< 0.036 °C) at the confluence of the Shasta and was even less (< 0.012 °C) by the time water passed by the confluence of the Scott River (Table 3). Examination of these paired data indicate the that discharge has very little effect on the rate in which temperatures change (warm or cool) downstream of Iron Gate Dam to the Shasta River and the Scott River confluence for those months and discharges considered.

Table 1. Paired comparison of the change in monthly temperature (˚C) per river mile (T-Rate) downstream of Iron Gate Dam to just below the confluence of the Shasta River and Scott River. Mean monthly water temperatures and flow were calculated using daily data provided by the RBM -10 water temperature model and discharge estimates developed from the Index Sequential model run scenario developed to inform the Secretarial Determination process for the Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement (Perry et al. 2011). Bold table values identify simulation runs where the difference in mean monthly flow for each scenario exceeds 500 cfs.

	Shasta River Confluence															
	2012		2013		2014		2015		2016		2017		2018		2019	
	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)
March (BO)	0.029	3,008	0.032	2,893	0.010	3,494	**0.054**	**1,753**	0.016	5,244	0.053	2,697	0.020	3,497	**0.047**	**1,772**
March (KBRA)	0.028	2,956	0.033	2,714	0.010	3,339	**0.034**	**2,637**	0.016	4,788	0.046	3,080	0.020	3,184	**0.025**	**2,775**
April (BO)	**0.061**	**1,736**	**0.048**	**3,034**	0.027	3,358	**0.069**	**1,735**	**0.039**	**4,419**	0.081	1,918	0.020	3,520	0.038	1,709
April (KBRA)	**0.042**	**2,482**	**0.061**	**2,464**	0.028	3,642	**0.048**	**2,541**	**0.042**	**3,705**	0.045	3,283	0.022	3,347	0.035	2,175
May (BO)	0.056	1,941	0.026	2,600	0.067	2,964	**0.076**	**1,614**	**0.034**	**3,463**	0.067	2,163	**0.063**	**3,288**	0.063	1,652
May (KBRA)	0.056	1,950	0.029	2,445	0.067	3,007	**0.051**	**2,433**	**0.041**	**2,937**	0.054	2,584	**0.050**	**4,079**	0.073	1,409
June (BO)	0.087	1,630	0.072	1,724	**0.040**	**1,796**	**0.075**	**1,360**	0.039	2,487	0.054	1,637	**0.065**	**1,942**	0.075	1,353
June (KBRA)	0.087	1,644	0.066	1,890	**0.032**	**2,289**	**0.048**	**2,011**	0.043	2,338	0.051	1,789	**0.046**	**2,715**	0.093	1,097

	Scott River Confluence															
	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)
March (BO)	0.014	3,986	0.022	3,517	0.003	4,131	**0.034**	**2,357**	0.011	5,966	0.031	3,658	0.008	4,348	**0.021**	**2,591**
March (KBRA)	0.014	3,934	0.021	3,338	0.003	3,977	**0.024**	**3,241**	0.010	5,510	0.028	4,041	0.007	4,036	**0.010**	**3,594**
April (BO)	**0.021**	**2,653**	**0.027**	**4,017**	0.008	4,664	**0.035**	**2,460**	**0.022**	**5,748**	**0.029**	**3,269**	0.005	4,124	0.001	2,282
April (KBRA)	**0.015**	**3,398**	**0.035**	**3,447**	0.009	4,948	**0.026**	**3,267**	**0.022**	**5,034**	**0.017**	**4,633**	0.006	3,951	0.004	2,748
May (BO)	0.014	2,905	-0.007	3,412	0.046	4,515	**0.032**	**2,396**	**0.007**	**4,572**	0.027	3,342	**0.045**	**4,823**	0.024	2,245
May (KBRA)	0.014	2,914	-0.006	3,257	0.047	4,557	**0.023**	**3,215**	**0.010**	**4,046**	0.022	3,762	**0.035**	**5,614**	0.026	2,002
June (BO)	0.034	2,441	0.031	2,185	-0.002	2,372	**0.025**	**1,998**	0.008	3,140	0.005	2,144	**0.015**	**3,045**	0.025	1,678
June (KBRA)	0.035	2,455	0.029	2,351	-0.002	2,865	**0.015**	**2,648**	0.009	2,991	0.005	2,296	**0.010**	**3,818**	0.030	1,422

Table 2. Paired comparison of the change in monthly water temperature (˚C) downstream of Iron Gate Dam to below the confluence of the Shasta River and Scott River (T-Delta). Mean monthly water temperatures and flow were calculated using daily data provided by the RBM -10 water temperature model and discharge estimates developed from the Index Sequential model run scenario developed to inform the Secretarial Determination process for the Klamath Hydroelectric Settlement Agreement and Klamath Basin Restoration Agreement (Perry et al. 2011). Bold table values identify simulation runs where the difference in mean monthly flow for each paired scenario exceeds 500 cfs.

	Shasta River Confluence															
	2012		2013		2014		2015		2016		2017		2018		2019	
	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)
March (BO)	0.40	3,008	0.44	2,893	0.14	3,494	**0.75**	**1,753**	0.22	5,244	0.74	2,697	0.28	3,497	**0.66**	**1,772**
March (KBRA)	0.40	2,956	0.46	2,714	0.14	3,339	**0.47**	**2,637**	0.23	4,788	0.65	3,080	0.28	3,184	**0.35**	**2,775**
April (BO)	**0.85**	**1,736**	**0.68**	**3,034**	0.38	3,358	**0.97**	**1,735**	**0.54**	**4,419**	**1.14**	**1,918**	0.28	3,520	0.53	1,709
April (KBRA)	**0.58**	**2,482**	**0.86**	**2,464**	0.39	3,642	**0.67**	**2,541**	**0.58**	**3,705**	**0.63**	**3,283**	0.31	3,347	0.49	2,175
May (BO)	0.78	1,941	0.37	2,600	0.94	2,964	**1.06**	**1,614**	**0.48**	**3,463**	0.94	2,163	**0.89**	**3,288**	0.88	1,652
May (KBRA)	0.78	1,950	0.40	2,445	0.94	3,007	**0.71**	**2,433**	**0.57**	**2,937**	0.76	2,584	**0.70**	**4,079**	1.02	1,409
June (BO)	1.21	1,630	1.01	1,724	0.56	**1,796**	**1.04**	**1,360**	0.55	2,487	0.76	1,637	**0.91**	**1,942**	1.05	1,353
June (KBRA)	1.21	1,644	0.92	1,890	0.45	**2,289**	**0.67**	**2,011**	0.60	2,338	0.71	1,789	**0.64**	**2,715**	1.30	1,097

	Scott River Confluence															
	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)	T-Delta	Flow (CFS)
March (BO)	0.66	3,986	1.03	3,517	1.62	4,131	**1.62**	**2,357**	0.49	5,966	1.44	3,658	0.36	4,348	**1.01**	**2,591**
March (KBRA)	0.66	3,934	1.00	3,338	1.13	3,977	**1.13**	**3,241**	0.47	5,510	1.29	4,041	0.34	4,036	**0.48**	**3,594**
April (BO)	**1.01**	**2,653**	**1.28**	**4,017**	1.64	4,664	**1.64**	**2,460**	**1.05**	**5,748**	**1.35**	**3,269**	0.25	4,124	0.04	2,282
April (KBRA)	**0.73**	**3,398**	**1.62**	**3,447**	1.21	4,948	**1.21**	**3,267**	**1.03**	**5,034**	**0.80**	**4,633**	0.29	3,951	0.21	2,748
May (BO)	0.66	2,905	-0.32	3,412	1.51	4,515	**1.51**	**2,396**	**0.35**	**4,572**	1.29	3,342	**2.14**	**4,823**	1.15	2,245
May (KBRA)	0.64	2,914	-0.29	3,257	1.10	4,557	**1.10**	**3,215**	**0.48**	**4,046**	1.04	3,762	**1.63**	**5,614**	1.24	2,002
June (BO)	1.62	2,441	1.47	2,185	1.19	2,372	**1.19**	**1,998**	0.37	3,140	0.25	2,144	**0.71**	**3,045**	1.18	1,678
June (KBRA)	1.64	2,455	1.35	2,351	0.72	2,865	**0.72**	**2,648**	0.44	2,991	0.24	2,296	**0.49**	**3,818**	1.41	1,422

Table 3. The difference in the mean monthly temperature rate (˚C/River Mile) and river flow (cfs) values calculated from the estimated water temperature rate changes and discharges presented in Table 1 for the Klamath River between Iron Gate Dam and the confluence of the Shasta and Scott Rivers. Values in bold font identify estimates where the differences in discharge exceed 500 cfs.

	2012		2013		2014		2015		2016		2017		2018		2019	
	Shasta River Confluence															
	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)
March	0.0002	52	0.0016	179	0.0002	155	**0.0200**	**884**	0.0005	456	0.0067	383	0.0005	312	**0.0226**	**1003**
April	**0.0193**	**745**	**0.0129**	**570**	0.0007	284	**0.0210**	**807**	**0.0031**	**714**	**0.0360**	**1364**	0.0024	173	0.0029	466
May	0.0000	9	0.0023	154	0.0002	43	**0.0253**	**819**	**0.0065**	**526**	0.0127	421	**0.0131**	**791**	0.0099	243
June	0.0000	14	0.0064	166	0.0081	493	**0.0267**	**651**	0.0038	149	0.0031	152	**0.0193**	**774**	0.0181	256
	Scott River Confluence															
	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)	T-Rate	Flow (CFS)
March	0.0001	52	0.0006	179	0.0002	155	**0.0104**	**884**	0.0005	456	0.0031	383	0.0005	312	**0.0113**	**1003**
April	**0.0060**	**745**	**0.0073**	**570**	0.0004	284	**0.0091**	**807**	**0.0004**	**714**	**0.0116**	**1364**	0.0007	173	0.0036	466
May	0.0005	9	0.0007	154	0.0003	43	**0.0088**	**819**	**0.0028**	**526**	0.0053	421	**0.0108**	**791**	0.0020	243
June	0.0004	14	0.0026	166	0.0002	493	**0.0101**	**651**	0.0016	149	0.0004	152	**0.0046**	**774**	0.0049	256

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