United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer To:
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March 29, 2019

Memorandum

To: Area Manager, Bureau of Reclamation Klamath Basin Area Office
Klamath Falls, Oregon

From: Michael Senn, Deputy Assistant Regional Director – Ecological Services,
U.S. Fish and Wildlife Service Pacific Southwest Region, Sacramento, California

Subject: Transmittal of Biological Opinion on Klamath Project Operations

Thank you for your December 21, 2018, letter requesting initiation of formal consultation with the U.S. Fish and Wildlife Service (Service) 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, USFWS received memoranda describing changes to the proposed action on February 15, 2019, March 8, 2019, and March 25, 2019.

This letter transmits the Service's biological opinion for the U.S. Bureau of Reclamation's (Reclamation's) proposed operation of the Klamath Project from April 1, 2019, to March 31, 2024, which describes the Service's analysis of the effects of Reclamation's implementation of proposed action on endangered Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). This biological opinion has been coordinated with the National Marine Fisheries Service to ensure compatibility with their biological opinion on the effects to species over which they have jurisdiction.

Based on the best available scientific and commercial information, the Service concludes that the action, as proposed, is not likely to jeopardize the continued existence of the Lost River sucker and shortnose sucker and is not likely to result in the destruction or adverse modification of critical habitat for Lost River sucker and shortnose sucker. However, the Service does anticipate incidental take of Lost River sucker and shortnose sucker as well as adverse effects to their designated critical habitat as a result of implementation of the proposed action.

The Service appreciates Reclamation's close coordination and collaboration throughout the development of the proposed action and consultation period to meet the needs of endangered species with the proposed action. We look forward to providing appropriate assistance to Reclamation during implementation of the proposed action. If you have any questions regarding this biological opinion, please contact Daniel Blake, Field Supervisor of the Klamath Falls Fish and Wildlife Office, at (541) 885-2512.

Attachment

cc: w/ attachment
Jim Simondet, NMFS, Northern California Office
Lisa Van Atta, NMFS, California Coastal Office

Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker

(TAILS # 08EKLA00-2019-F-0068)

Prepared By:

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

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Definition
ac	acres
ACFFOD	Amended and Corrected Findings of Fact and Order of Determination
ACT	Agency Coordination Team
AF	acre-feet
AFA	*Aphanizomenon flos-aquae*
BA	Biological Assessment
BiOp	Biological Opinion
° C	degrees Celsius
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
DDT	Dichlorodiphenyltrichloroethane
DO	dissolved oxygen
ESA	Endangered Species Act
EWA	Environmental Water Account
FASTA	Flow Account Scheduling Technical Advisory
° F	degrees Fahrenheit
FES	Fish Evaluation Station
FR	Federal Register
ft	feet
ha	hectares
HCP	Habitat Conservation Plan
HID	Horesfly Irrigation District
IGD	Iron Gate Dam
in	inches
ITS	Incidental Take Statement
KBAO	Klamath Basin Area Office
KBPM	Klamath Basin Planning Model
KDD	Klamath Drainage District
KHP	Klamath Hydroee
KID	Klamath Irrigation District
KLS	Klamath Largescale Sucker
KSD	Klamath Straits Dam
LKNWR	Lower Klamath National Wildlife Refuge
L	liter
LOESS	locally estimated scatterplot smoothing
LRD	Link River Dam
LRDC	Lost River Diversion Channel

LRS	Lost River sucker
LVID	Langell Valley Irrigation District
m	meters
mg	milligram
mm	millimeters
NMFS	National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
O&M	Operation and Maintenance
ODEQ	Oregon Department of Environmental Quality
OWRD	Oregon Water Resources Department
PA	proposed action
PBF	physical or biological features
PIT	Passive Integrated Transponder
POR	period of record
RPM	reasonable and prudent measure
SNS	shortnose sucker
SONCC	Southern Oregon/Northern California Coastal
SSA	species status assessment
SV	state variable
sec	seconds
TAF	thousand acre-feet
TID	Tulelake Irrigation District
TLNWR	Tule Lake National Wildlife Refuge
TMDL	Total Maximum Daily Load
UKL	Upper Klamath Lake
USBR	U.S. Bureau of Reclamation
USDI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service
WRIMS	Water Resources Integrated Modeling System
WY	Water Year

1 INTRODUCTION

This document transmits the biological opinion (BiOp) of the U.S. Fish and Wildlife Service (USFWS, Service) 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. The federally-listed species (hereafter referred to as listed species) and critical habitats considered in this document are Lost River sucker (*Deltistes luxatus*, LRS) and shortnose sucker (*Chasmistes brevirostris*; SNS), which were both listed as endangered in 1988 and have designated critical habitat. There are also listed species that fall under the jurisdiction of the National Marine Fisheries Service (NMFS) that are present in the action area. The effects of the Project on these species was considered in a separate, but coordinated, BiOp prepared by NMFS.

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 on December 21, 2018. Reclamation provided an addendum to their December 21 Biological Assessment on February 15, 2019.

This BiOp and the concurrence determinations are based on information provided in Reclamation's Final Biological Assessment (BA; USBR 2018a), including the addenda and clarifications received on February 15, 2019 and March 22, 2019, and other sources of information. A complete record of this consultation is on file at the USFWS office in Klamath Falls, Oregon.

2 BACKGROUND AND CONSULTATION HISTORY

2.1 Background

The Klamath Basin's hydrologic system 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 operated the Klamath Hydroelectric Project under a 50-year license issued by the Federal Energy Regulatory Commission until the license expired in 2006. PacifiCorp continues to operate the Klamath Hydroelectric Project under annual licenses based on the terms of the previous license. PacifiCorp and the Klamath River Renewal Corporation have proposed to decommission and remove four of the Klamath Hydroelectric Project dams: J.C. Boyle, Copco 1 and 2, and IGD. The effects of that action on endangered species will be considered in a separate biological opinion.

A series of BiOps on Project operations have been completed since the USFWS listed the Lost River and shortnose suckers as endangered on July 18, 1988. NMFS listed the Southern Oregon/Northern California Coastal (SONCC) coho salmon on May 6, 1997, and NMFS and USFWS completed separate Biological Opinions on Project operations between the SONCC coho salmon listing and 2010. Under USFWS's 2008 BiOp and the Reasonable and Prudent

Alternative from NMFS's 2010 jeopardy BiOp, Reclamation and the Services agreed that Reclamation was unable to meet the water needs of the Project and the Services' BiOps under some hydrologic conditions, resulting in conflicting requirements that were difficult for Reclamation to meet with actions under its discretion. Therefore, NMFS and USFWS elected to complete a joint BiOp on Project operations. The goal of the joint BiOp 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. The final joint BiOp was issued on May 31, 2013. More details on the specific consultations that were issued prior to 2013 and the associated litigation are provided in Reclamation's 2018 BA and the 2013 BiOp.

2.2 History of Consultation

In late 2016, in connection with two related cases in the U.S. District Court for the Northern District of California, Yurok Tribe v. Bureau of Reclamation, No. 16-cv-6863, and Hoopa Valley Tribe v. Bureau of Reclamation, No. 16-cv-4294, Reclamation was required to provide certain flows in the Klamath River for the stated purpose of disease mitigation for coho salmon in the Klamath River until such time that the Klamath ROC is complete (Court Order; March 24, 2017; Case Nos. 3:16-cv-06863-WHO and C16-cv-04294-WHO.)

The federal district court issued an order for injunctive relief on March 24, 2017, requiring Reclamation to implement three types of flows intended to reduce and mitigate the effects of *Ceratonova shasta* on coho salmon in the Klamath River: surface flushing flows, deep flushing flows, and reservation of 50,000 acre-feet by April one of each year for potential implementation of emergency dilution flows. The court ordered that these flows be implemented until consultation was completed.

In 2017, Reclamation formally reinitiated consultation with NMFS and USFWS pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1531 et seq.) on the continued operation of the Klamath Project in response to consecutive years of drought and the 2014 and 2015 exceedance of incidental take of coho salmon – included in the 2013 BiOp incidental take statement. Reclamation's Klamath Project reinitiation of consultation (Klamath ROC) consists of analyzing Reclamation's proposed action to implement a modified water management approach for Project operations providing water supply reliability for Project irrigators, while addressing ESA requirements for listed species and/or designated Critical Habitat. Reclamation provided a Final Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project from April 1, 2019, through March 31, 2024, to the Services on December 21, 2018, and associated addenda on February 15, 2019 and March 22, 2019, (modified 2018 Biological Assessment [BA]).

This BiOp represents a multi-year coordinated effort among Reclamation, USFWS, and NMFS to develop a modified proposed action for ongoing Project operations. The Agency Coordination Team (ACT), a team of federal resource managers including hydrologists, biologists, and managers from each agency and support staff, met numerous times starting in January 2017 to try to address issues identified in the 2013 BiOp in the development of the modified proposed action (Table 2-1). Reclamation also engaged in a process to include tribes and key stakeholders in the development process. A number of meetings were held and opportunities to provide feedback on draft documents were provided (Table 2-1).

Table 2-1. Chronology of agency coordination meetings for development of Reclamation's proposed action.

Meeting Type	Date Held	Location
Reclamation and the Services Meetings and Work Sessions		
ACT	1/31/2017	webinar/teleconference
ACT	2/15/2017	Ashland, OR
ACT	4/5/2017	Ashland, OR
ACT	5/24/2017	webinar/teleconference
ACT	6/12/2017	webinar/teleconference
ACT	7/6/2017	webinar/teleconference
ACT	7/12/2017	webinar/teleconference
ACT	8/1/2017	webinar/teleconference
ACT	8/22/2017	Medford, OR
ACT	9/27/2017	Klamath Falls, OR
ACT	10/20/2017	webinar/teleconference
ACT	11/30/2017	webinar/teleconference
ACT	12/14/2017	webinar/teleconference
ACT	2/20/2017	webinar/teleconference
ACT	4/17/2018	webinar/teleconference
ACT	5/15/2018	Grants Pass, OR
ACT	6/22/2018	webinar/teleconference
ACT	7/25/2018	webinar/teleconference
ACT	8/7/2018	webinar/teleconference
ACT	8/23/2018	webinar/teleconference
ACT	9/21/2018	Selma, OR
ACT	10/24/2018	webinar/teleconference
ACT	11/27/2018	webinar/teleconference
Tri-Agency Hydro Team	10/11/2017	webinar/teleconference
Tri-Agency Hydro Team	11/2/2017	webinar/teleconference
Tri-Agency Hydro Team	11/30/2017	webinar/teleconference
Tri-Agency Hydro Team	12/4/2017	webinar/teleconference
Tri-Agency Hydro Team	12/12/2017	webinar/teleconference
Tri-Agency Hydro Team	1/11/2018	webinar/teleconference
Tri-Agency Hydro Team	1/29/2018	webinar/teleconference
Tri-Agency Hydro Team	2/5/2018	Ashland. OR
Tri-Agency Hydro Team	2/21/2018	webinar/teleconference
Tri-Agency Hydro Team	4/17/2018	webinar/teleconference
Tri-Agency Hydro Team	4/24/2018	Ashland, OR
Tri-Agency Hydro Team	4/25/2018	Ashland, OR

Tri-Agency Hydro Team	5/14/2018	webinar/teleconference
Tri-Agency Hydro Team	6/8/2018	webinar/teleconference
Tri-Agency Hydro Team	6/21/2018	Klamath Falls, OR
Tri-Agency Hydro Team	7/11/2018	webinar/teleconference
Tri-Agency Hydro Team	7/16/2018	webinar/teleconference
Tri-Agency Hydro Team	7/24/2018	webinar/teleconference
Tri-Agency Hydro Team	8/6/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/16/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/22/2018	webinar/teleconference
Tri-Agency Hydro Team	8/28/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/29/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/30/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/11/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/12/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/19/2018	webinar/teleconference
Tri-Agency Hydro Team	9/24/2018	webinar/teleconference
Tri-Agency Hydro Team	10/3/2018	webinar/teleconference
Tri-Agency Hydro Team	10/4/2018	webinar/teleconference
Tri-Agency Hydro Team	10/11/2018	webinar/teleconference
Tri-Agency Hydro Team	10/25/2018	webinar/teleconference
Tri-Agency Bio Team	8/15/2017	Teleconference
Tri-Agency Bio Team	11/1/2017	Teleconference
Tri-Agency Bio Team	6/18/2018	Teleconference
Tri-Agency Bio Team	6/20/2018	Teleconference
Tribal and Key Stakeholder Workshops and Meetings		
Tribal and Key Stakeholder Policy Workshop	7/24/2017	Klamath Falls, OR
Tribal and Key Stakeholder Policy Workshop	7/25/2017	Klamath Falls, OR
Tribal and Key Stakeholder Policy Workshop	9/27/2017	Klamath Falls, OR
Tribal and Key Stakeholder Policy Workshop	12/5/2017	webinar/teleconference
Tribal and Key Stakeholder Policy Workshop in the Morning with Individual Tribal and Key Stakeholder Meetings in the Afternoon	11/13/18	Klamath Falls, OR
Tribal and Key Stakeholder Technical Team (Hydro Members only)	10/17/2017	webinar/teleconference
Tribal and Key Stakeholder Technical Team	11/13/2017	Klamath Falls, OR
Tribal and Key Stakeholder Technical Team	12/15/2017	webinar/teleconference
Tribal and Key Stakeholder Technical Team	1/9/2018	Redding, CA
Tribal and Key Stakeholder Technical Team	2/6/2018	Ashland, OR
Tribal and Key Stakeholder Technical Team	11/8/18 and 11/9/18	webinar/teleconference

On December 21, 2018, Reclamation sent a letter and the accompanying BA to USFWS pursuant to section 7(a)(2) of the ESA. An addendum to the BA, modifying the period of the action from 10 years to 5 years, adding enhanced May/June river flows to support coho salmon habitat, and adjusting the proposed minimum on Tule Lake from 4,034.6 ft (1,229.8 m) to 4034.0 ft (1,229.6 m) was received on February 15, 2019.

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).

The action area is located in the Klamath River watershed in southern Oregon and northern California (Figure 3-1), including all Project reservoirs, water transport structures, and irrigated lands, as well as the Klamath River downstream to the Pacific Ocean. Within the Upper Klamath Basin, the action area covers Agency Lake, Upper Klamath Lake, Keno Reservoir (also known as Lake Ewauna or Keno Impoundment), Gerber Reservoir, Clear Lake (also known as Clear Lake Reservoir), the Tule Lake sumps, the Lost River including Miller Creek (Figure 3-1), and all Project-influenced areas, including reservoirs, diversion channels and dams, canals, laterals, drains, and areas within Tule Lake and Lower Klamath National Wildlife Refuges (Figure 3-2). Although Project operations do not occur in tributaries to UKL, the Sprague River below the former Chiloquin Dam site is also included in the action area because conservation measures for listed suckers are proposed to occur in these tributaries.

The action area also includes the mainstem Klamath River from IGD at River Mile 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.

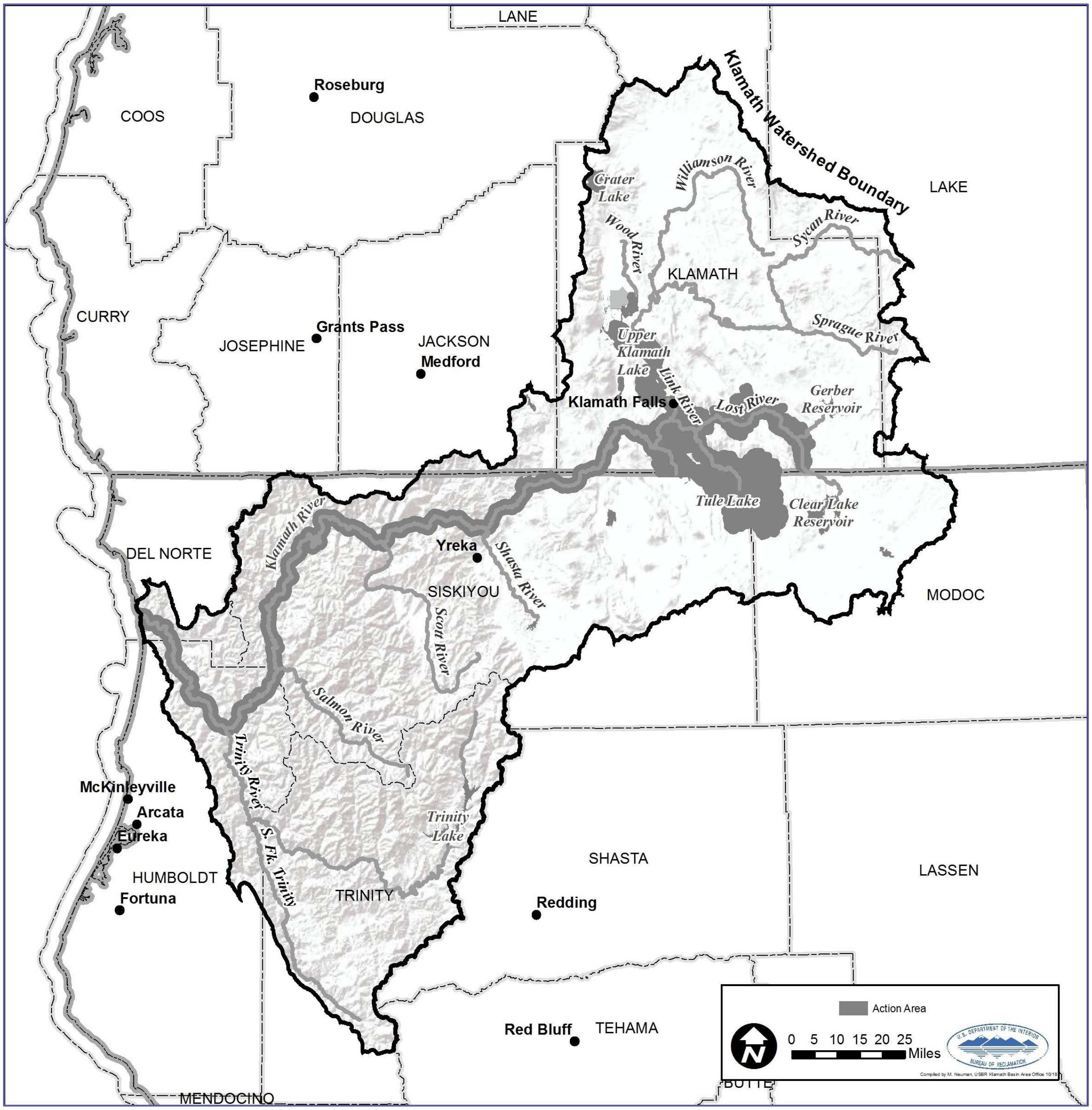


Figure 3-1. The action area for Reclamation's proposed action (USBR 2018a Figure 4-2).

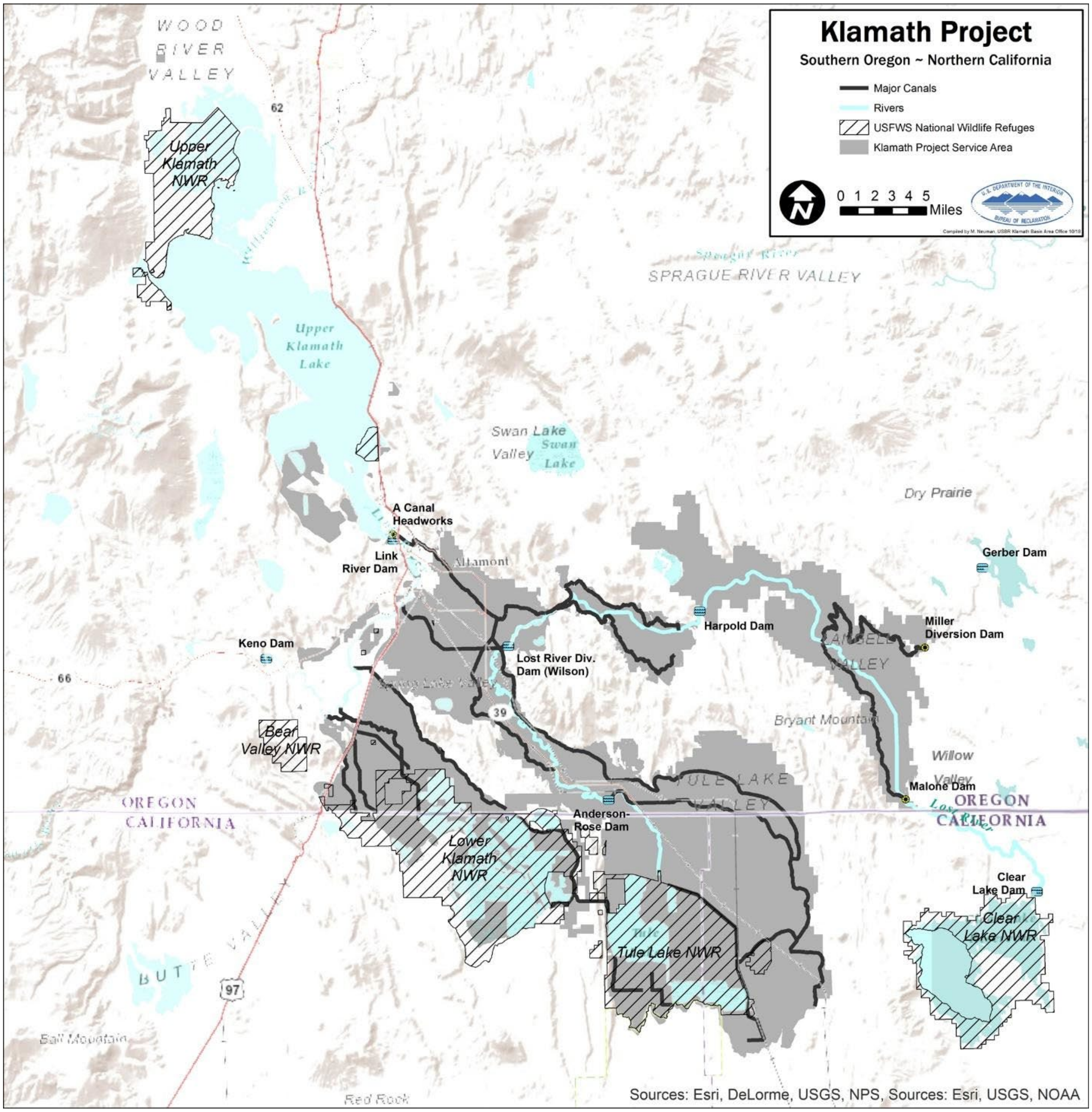


Figure 3-2. Location of the Project in the Upper Klamath River Basin of Oregon and California (USBR 2018a Figure 4-1).

4 PROPOSED ACTION

Reclamation has managed UKL elevations (since 1991) and Klamath River flows at IGD (since 2001) in accordance with a series of Opinions from the Services. For the 2012 BA, Reclamation, in consultation with USFWS and NMFS, utilized the Klamath Basin Planning Model (KBPM) to simulate operations of the Project for the 1981 through 2011 period of record (POR) of historical hydrology for development of the Proposed Action (PA). For the current consultation effort, Reclamation has made substantial improvements to the KBPM structure and has incorporated data updates and refinements, including: incorporating recent data to expand the POR from 2011 through 2016 (i.e., 1981 to 2016), revised accretions and UKL inflow datasets, a new UKL bathymetric layer, updated UKL net inflow estimates for the POR, and updated daily Project diversion data and return flows for the POR. Project operations using facilities that store and divert water from UKL and the Klamath River were simulated in the KBPM over a wide range of hydrologic conditions for the period of October 1, 1980, through November 30, 2016, using daily input data to obtain daily, weekly, monthly, and annual results for river flows, UKL elevations, and Project diversions including deliveries to the Lower Klamath National Wildlife Refuge (LKNWR). The resulting simulations produced estimates of the water supply available from the Klamath River system (including UKL) for the POR. Under implementation of the proposed action, Reclamation will develop an operational model (IGD calculator) that incorporates KBPM logic from the final proposed action model run (PA_Final_02142019) to be utilized for real-time operations.

The KBPM is a planning tool that assisted in the development of the PA and not all the processes built into the model can be implemented during actual operations. In addition, it is important to be aware of the critical assumptions that are incorporated into the KBPM. Listed below are the critical assumptions that have been identified for the KBPM. This list provides examples of how some of the processes built into the KBPM cannot be, and are not intended to be implemented, during real-time operations.

Critical KBPM assumptions include:

- The upper Klamath River basin will experience WY types within the range observed in the POR.
- UKL inflows will be within the range observed in the POR.
- NRCS inflow forecasts will be within the range and accuracy of historical inflow forecasts.
- UKL bathymetry in the model is reasonably representative of actual UKL bathymetry and therefore accurately represents UKL storage capacity.
- Water deliveries to the Project will be consistent with distribution patterns analyzed for the KBPM.
- Accretions from LRD to IGD will be consistent with accretion timing, magnitude, and volume assumed in the KBPM.
- Accretions from LRD to IGD will be routed through PacifiCorp’s hydroelectric reach in a manner that is consistent with the KBPM model results for the POR.
- Facility operational constraints and limitations, and/or associated maintenance activities, will be within the historical range for the POR.

- Implementation of the proposed action will not exactly replicate the modeled results, and actual IGD flows and UKL elevations will differ during real-time operations.

A complete and detailed explanation of the PA and the updates to the model utilized in development of the PA can be found in Reclamation's Klamath Project Operations Biological Assessment, Part 4: Proposed Action and Appendix 4 (USBR 2018a pp. 55–103, Appendix 4).

Note that the February 15, 2019 addendum to the BA has been fully considered and incorporated into the description that follows.

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, 2024.

Reclamation's proposed Project operations from 2019 to 2024 consist of three major elements:

1. Store waters of the Upper Klamath Basin and Lost Rivers.

2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, National Wildlife Refuge needs, or releases for flood control purposes, subject to water availability; while maintaining conditions in UKL and Klamath River that meet the legal requirements under section 7 of the ESA.

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 Upper Klamath Basin and Lost River.

4.2 Annual Storage of Water

Reclamation operates three reservoirs for the purpose of storing water for delivery to the Project's service area - UKL, and Clear Lake and Gerber reservoirs.

Bathymetric data compiled by Reclamation in 2017 (including nearshore areas such as Upper Klamath National Wildlife Refuge, and Tulana and Goose Bays), indicated an "active" storage volume of 562,000 AF between the elevations of 4,136.0 and 4,143.3 feet above sea level (USBR datum), which is the historical range of water surface elevations within which UKL has been operated. See Part 6.3 in Reclamation's 2018 BA for additional details regarding historical conditions in UKL.

Clear Lake Reservoir has an active storage capacity of 467,850 AF (between 4,521.0 and 4,543.0 feet above sea level, Reclamation datum), of which 139,250 AF is exclusively reserved for flood control purposes (between 4,537.4 and 4,543.0 feet above sea level, USBR datum).

Gerber Reservoir has an active storage capacity of 94,270 AF (between 4,780.0 and 4,835.4 feet above sea level, USBR datum). No storage capacity in Gerber Reservoir is exclusively reserved for flood control purposes.

Reclamation proposes to store water annually in UKL and Clear Lake and Gerber reservoirs with the majority of inflow occurring from October through April. In some years of high net inflows or atypical inflow patterns (i.e., significant snowfall or other unusual hydrology in late spring/early summer), contributions to the total volume stored can also be significant in May and June. The majority of wa ter delivery from storage occurs during March through September, although storage releases for irrigation purposes occur year-round. Storing water through the winter and spring results in peak lake and reservoir storage between March and May. Flood control releases may occur at any time of year, as public safety, operational, storage, and inflow conditions warrant.

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 562,000 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 to a lesser extent, preceding years.

4.2.1 UKL Flood Prevention Threshold Elevations

Maximum UKL flood control elevations are utilized as a guideline in an attempt to provide adequate storage capacity in UKL to capture high runoff events, to avoid potential levee failure due to overfilling UKL, and to mitigate flood conditions that may develop in the Keno plain upstream of Keno Dam. The general process of flood control consists of spilling water from UKL when necessary to prevent elevations from increasing above flood pool elevations, which change throughout the year in response to inflow forecasts and experienced hydrology. Flood pool elevation is calculated each day to create a smooth UKL operation, allowing UKL to fill (i.e., approach 4143.3 ft) by the end of March in drier years and by the end of April in wetter years. The UKL flood control elevations are intended to be used as guidance, and professional judgment will be utilized in combination with hydrologic conditions, snowpack, forecasted precipitation, public safety, and other factors in the actual operation of UKL during flood control operations.

The flood control elevations are set at 4,141.4 feet in September and October and then increase from 4,141.4 to 4,141.8 feet from November 1 through December 31 (daily values are obtained through interpolation). In most years, there are no flood control releases during these months.

From January 1 through April 30, the UKL flood control elevations are determined based on the forecasted inflow and the day of the month. The Natural Resources Conservation Service (NRCS) UKL net inflow forecast is used to determine the end of month flood control elevation and the daily flood control elevation is linearly interpolated between the current end of month elevation and the previous month's end of month flood control elevation.

Additionally, UKL flood control elevations vary between wet and dry year types. The distinction is based on the NRCS March through September 50 percent exceedance forecast for UKL net inflow issued in January, February, and March. The forecast issued in March is used for both March and April. If the forecast March through September net UKL inflow is greater than 710,000 AF, the water year is considered wet; the water year is considered dry if the forecast net inflow is equal to or less than 710,000 AF. Once the water year is determined to be wet or dry, the UKL flood control elevations identified in Table 4-1 will be used for operations in that given water year. The flood control curves and flood control operations are consistent with what has been implemented under the 2013 BiOp.

Reclamation retains sole discretion to determine when to initiate or cease flood control operations.

Table 4-1. UKL flood release threshold elevations for the last day of each month under 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)

4.3 Element Two

Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes (including NWR needs), subject to water availability, and consistent with flood control purposes, while maintaining UKL and Klamath river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.

4.3.1 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 flood operation and control 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 may be 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 may also be reused several times.

A key component of water management on the west side of the Project is the monthly NRCS seasonal water supply forecast for UKL inflow. 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 pp. 1, 42–43). NRCS provides an official monthly forecast from the forecast month through September on the first of each month from January to June; a mid-month forecast is also provided but not used for calculation of monthly water allocations. The forecasts are used to estimate seasonal net inflow to UKL and in models used to simulate water management scenarios for the Project, UKL, Klamath River, and refuges. The inflow forecasts are seasonal volumetric estimates; actual observed inflow volumes and timing may vary substantially from forecasted inflows, particularly over shorter time periods.

A detailed description of the NRCS inflow forecasting procedures is located at the following NRCS web sites: https://www.wcc.nrcs.usda.gov/about/forecasting.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 historical period of record (POR), which encompasses water years 1981 through 2016. 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 5-year period of this proposed action.

4.3.2 Operation and Delivery of Water from UKL and the Klamath River

The portion of the Project served by UKL and the Klamath River consists of approximately 200,000 acres of irrigable land, including areas around UKL, along the Klamath River (from Lake Ewauna to the town of Keno), Lower Klamath Lake, and from Klamath Falls to Tulelake. Most irrigation deliveries occur between April and October, although water is diverted year-round for irrigation use within the Project.

Stored water and live flow in UKL are directly diverted from UKL, via the A Canal and smaller, privately-owned diversions. Consistent with state water law and as applicable to the Klamath Project, the term "live flow" encompasses surface water in natural waterways that has not otherwise been released from storage (i.e., "stored water"). Live flow can consist of tributary runoff, spring discharge, return flows, and water from other sources such as municipal or industrial discharge (USBR 2018a p. 63). The A Canal (1,150 cubic feet per second [cfs] capacity) and the connected secondary canals it discharges into (i.e., the B, C, D, E, F, and G canals) serve approximately 71,000 acres within the Project. In addition to the A Canal, there are approximately 8,000 acres around UKL that are irrigated by direct diversions from UKL under water supply contracts with Reclamation.

In addition to direct diversions from UKL, stored water and live flow is released from Link River Dam (LRD), for re-diversion from the Klamath River between Klamath Falls and the town of Keno. PacifiCorp currently operates LRD under guidance from Reclamation to achieve certain flows at IGD.

Water released from LRD flows into the Link River, a 1.5-mile waterbody that discharges into Lake Ewauna, which is the start of the Klamath River. The approximately 16-mile section of the Klamath River between the outlet of Link River and Keno Dam is commonly referred to as the Keno Impoundment, Keno Reservoir, or Lake Ewauna (referred to as the Keno Impoundment herein).

There are three primary points of diversion along the Keno Impoundment that are used to re-divert stored water and live flow released from UKL via the LRD. Approximately 3 miles below the outlet of Link River, water is diverted into the Lost River Diversion Channel (LRDC), where it can then be pumped or released for irrigation use. Pumping from the LRDC primarily occurs at the Miller Hill Pumping Plant (105 cfs capacity), which is used to supplement water in the C-4 Lateral for serving lands within Klamath Irrigation District (KID) that otherwise receive water through the A Canal. KID operates and maintains the Miller Hill Pumping Plant. In addition to the Miller Hill Pumping Plant, there are other smaller, privately-owned pumps along the LRDC that serve individual tracts within KID. Water re-diverted into the LRDC can also be released through Station 48 (650 cfs maximum capacity), where it is then discharged into the Lost River below the Lost River Diversion Dam for re-diversion and irrigation use downstream. Tulelake Irrigation District (TID) makes gate changes at Station 48 based on irrigation demands in the J Canal system, which serves approximately 62,000 acres within KID and TID. To the extent that live and return flows in the Lost River at Anderson-Rose Dam and the headworks of the J Canal (810 cfs capacity) are insufficient to meet associated irrigation demands, water is released from

Station 48 to augment the available supply.

The other two primary points of diversion along the Keno Impoundment that re-divert stored water and live flow from UKL are the North and Ady canals (200 cfs and 400 cfs capacity, respectively), which are owned and operated by Klamath Drainage District (KDD). In addition to lands within the boundaries of KDD, the Ady Canal also delivers water to the California portion of LKNWR. Together, the North and Ady canals deliver water to approximately 45,000 acres of irrigable lands in the Lower Klamath Lake area, including lands in KDD.

In addition to the lands served by the LRDC and Ady and North canals, Reclamation has entered into water supply contracts covering approximately 4,300 acres along the Keno Reservoir, including lands on the west side of the Klamath River and on Miller Island. Privately-owned pumps are generally used to serve these lands.

Demands for irrigation supply and refuge deliveries over the proposed lifetime of this BA are assumed to be similar to those that have occurred in the 36-year POR for water-year 1981 through 2016. However, continued improvements in irrigation infrastructure and equipment combined with advances in irrigation practices and technology will likely help to reduce Project irrigation demand in the future. The irrigation "demand" is the amount of water required to fully satisfy the irrigation needs of the Project. While these historical demands are retained for analysis and comparison purposes, irrigation deliveries to the Project within this PA were modeled using the Agricultural Water Delivery Sub-model (USBR 2018a Appendix 4). Modeled deliveries during this 36-year POR generally fall within the range of historical Project deliveries. In addition, the POR exhibits a large range of hydrologic and meteorological conditions, and the various modeled deliveries during this period are reasonably expected to include the range of conditions likely to occur during the proposed term of this BA.

Water management in the fall/winter operations period (November 1 – February 28/29 for the Project and from October 1 – February 28/29 for the Klamath River), employs a formulaic management approach focused on maintaining conditions in UKL and the Klamath River that meet the needs of the ESA-listed species as described in this BA, and provide fall/winter water deliveries to the Project and LKNWR. This approach attempts to ensure appropriate water storage and sucker habitat in UKL while providing Klamath River flows that intend to represent current conditions in the upper Klamath Basin.

Water management in the spring/summer operational period includes March 1 – November 30 for Area A1 and March 1 – October 31 for Area A2. Limited overlap between spring/summer operations in Area A1 and fall/winter operations in October and November remains; in other words, as in the 2012 BA and 2013 BiOp, Area A1 may continue diverting spring/summer water (i.e., Project Supply; water available to the Project from UKL) after October 1, when the fall/winter period begins (*see* Sections 4.2.2.1 and 4.2.2.2 for additional details). Note that Area A1 includes Project lands served by A Canal and the LRDC including KID, TID, and water supply contracts and Districts served by KID. Area A2 includes KDD and LKNWR served by the Ady and North canals.

Generally, Reclamation proposes to determine the total available UKL Supply, accounting for sucker needs through the spring/summer period, and then distribute this supply between the Project and the Klamath River environmental water account (EWA). The division of the total available UKL water supply between EWA and Project Supply was determined through an iterative modeling process, relying on the expert opinion of Reclamation and the Services.

The PA management approach has two major components:

1. UKL elevations and storage, specifically the UKL control logic and UKL Credit, to protect sucker habitat and ensure adequate storage to meet the needs of listed species in UKL and the Klamath River and water supply for the Project; and

2. Klamath River flows, specifically EWA to support coho needs and to produce flows for disease mitigation or protection of coho habitat during the spring/summer operational period (between March 1 and September 30), and a formulaic approach for calculating IGD releases in the fall/winter (October 1 – February 28/29).

4.3.2.1 *Upper Klamath Lake*

This operational approach seeks to fill UKL during the fall/winter to increase the volumes available for the EWA (including disease mitigation or habitat flows), UKL, and Project Supply during the spring/summer operational period. The PA also includes a UKL control logic that regulates certain releases relative to UKL storage and recent hydrologic conditions in a manner that maintains UKL elevations important for suckers, and a UKL Credit that buffers UKL against uncertainties associated with NRCS forecast error and other factors affecting UKL inflow available for subsequent diversion.

The UKL control logic helps to manage UKL elevations for endangered suckers while ensuring adequate storage in UKL for both Klamath River and Project releases, utilizing a "central tendency." The central tendency is based on user-defined end-of-month UKL elevations that are subsequently interpolated to daily values. This results in a generic annual hydrograph that accounts for seasonal needs of suckers, seasonal water demand for the Klamath River and Project, and end-of-season elevations intended to result in storage volumes appropriate to meet the next year's demands on UKL. This generic hydrograph is then adjusted daily, based on a normalized 60-day trailing average of raw net inflow to UKL, resulting in an adjusted central tendency. If UKL elevations drop below the adjusted central tendency, then releases to the Klamath River and winter deliveries to Area A2 are reduced until UKL elevations equal or exceed the adjusted central tendency line. Reductions to Klamath River releases due to UKL control logic may not result in flows at IGD less than the proposed minimum IGD target flows. The adjusted central tendency is not a target to which UKL should be managed, but rather a guideline that maintains UKL elevations in line with both hydrologic conditions and the multiple demands placed upon UKL storage throughout the year.

The purpose of the UKL Credit is to hold water in UKL to facilitate establishing a minimum Project Supply on April 1 with no later reduction below the April 1 allocation, and the possibility of an increase in subsequent May 1 and June 1 allocations. Accrual of UKL Credit provides a volume of water in UKL that can be drawn upon in the case of an early season over-forecast of seasonal inflow to UKL. Any UKL Credit accrued in UKL above and beyond that necessary for full delivery of Project Supply will remain in UKL to facilitate refill of UKL in the ensuing fall/winter period. There is no carryover of accrued UKL Credit from season to season. UKL Credit can only be accrued from March 1 – September 30 during controlled flow conditions (i.e., not during flood control operations), and is accumulated when LRDC flows and Klamath Straits Dam (KSD) discharges in excess of direct diversions for irrigation are utilized to meet IGD flow targets, resulting in a reduction in LRD releases. In other words, when Project irrigators do not divert LRDC flow or KSD return flows and these unused volumes are utilized to offset LRD releases, a volume of water (the UKL Credit, equal to the reduction in LRD releases for river flows) is stored in UKL. As with current operations, Reclamation anticipates that PacifiCorp will adjust LRD releases as appropriate to meet IGD targets, accounting for these specific accretions to the Klamath River (i.e., if LRDC and KSD accretions increase, PacifiCorp would decrease LRD releases such that IGD targets are still met, but not exceeded). Reclamation will track accretions and IGD releases to properly calculate UKL credit.

Finally, note that the generic central tendency end-of-month UKL elevations were arrived at through the iterative modeling process and are not intended to change during operations under this PA. See Reclamation's 2018 BA Appendix 4, Section A.4.4.1.1 for technical details regarding the UKL control logic (USBR 2018a).

The KBPM output graphs provided in Appendix 4 of Reclamation's 2018 BA display the expected annual UKL and Klamath River hydrographs for the POR under implementation of the proposed action (USBR 2018a). Real-time operations will not exactly replicate the modeled results and actual flow and elevation variability will differ during real-time operations.

4.3.2.2 *Klamath River*

Reclamation is proposing to distribute EWA from UKL based on the EWA allocation, UKL control logic, UKL net inflow, and NRCS-forecasted March – September net inflow (50 percent exceedance) from March 1 – September 30. For the July 1 – September 30 period, Reclamation proposes to distribute EWA from UKL based on remaining EWA and UKL control logic. Reductions to Klamath River releases due to UKL control logic may not result in flows at IGD less than the proposed minimum IGD target flows identified in Table 4-2. The PA incorporates the augmented April, May, and June IGD minimums in the 2013 BiOp and explicitly provides additional water to mitigate disease and habitat issues in years with hydrology meeting specific criteria (Section 4.2.2.2). Finally, Reclamation proposes to retain IGD as a compliance point for Klamath River flows for the duration of this proposed action (see USBR 2018a pp. 49–52 for details about dam removal and associated implications for this PA).

Table 4-2. Proposed average daily minimum Iron Gate Dam target flows (cfs).

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
October	1,000 (28.3 m^3/sec)
November	1,000 (28.3 m^3/sec)
December	950 (26.9 m^3/sec)
January	950 (26.9 m^3/sec)
February	950 (26.9 m^3/sec)
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)

As in the 2013 BiOp, IGD targets in the fall/winter and a portion of the spring/summer period are calculated using a hydrologic indicator of upper Klamath Basin conditions. Specifically, Reclamation proposes to utilize the net inflow to UKL to calculate IGD targets throughout the fall/winter period and from March 1 through June 30 of the spring/summer period. For the remainder of the spring/summer period, from July 1 through September 30, EWA distribution is based on EWA allocation and UKL control logic (USBR 2018a pp. 76–79). The intent of this method is to create a hydrograph downstream of IGD that approximates a natural flow regime reflective of actual hydrologic conditions and variability occurring in the upper Klamath Basin. Net UKL inflow was chosen over the previously-utilized Williamson River discharge because Williamson River flow is only reflective of hydrology in a portion of the UKL watershed, namely the ground-water dominated north-central portion. UKL net inflow is preferable given that it also accounts for hydrologic conditions in the groundwater-dominated Wood River and snowmelt-runoff dominated tributaries originating in the Cascade Mountains. Additionally, daily UKL net inflow is calculated using a number of gages maintained by the USGS with consistent and reliable datasets over the POR. These gages are expected to remain in operation and the continued reliability of this hydrologic data is an important consideration to retain the ability to implement the PA in the future.

Utilizing UKL net inflow as the hydrologic indicator is expected to result in a flow regime with a similar timing and shape observed under the 2013 BiOp, with the exception that there is also sufficient EWA volume to implement disease mitigation or coho habitat-supporting flows in the

Klamath River (see USBR 2018a pp. 79–82 for additional details). IGD targets may also now be adjusted based on the UKL control logic.

The daily IGD target flows will be implemented 3 days after the hydrologic conditions are observed in the upper Klamath Basin. The actual transit time may be more or less than 3 days depending on the magnitude of the flow rate, elevation of UKL, and the hydrologic conditions downstream of UKL. The 3-day delay is not intended to precisely replicate hydrologic conditions in the Klamath River. Rather, the 3-day lead time is needed for IGD flow schedule planning purposes to accommodate PacifiCorp's operation of the Klamath Hydroelectric Project.

In the event of gage failure, professional judgment will be used in combination with all relevant hydrologic data to estimate UKL elevation and inflow, IGD releases, and/or LRD to IGD accretions. USGS gage failures occur infrequently and every attempt will be made to coordinate with USGS to appropriately estimate flow and/or elevation values whenever a gage failure occurs.

PacifiCorp's operation of the Klamath Hydroelectric Project will influence the timing and magnitude of the hydrograph downstream of IGD due to water travel time through the reservoirs and due to facilities operations. Under normal operating conditions, these influences are expected to be minimal because PacifiCorp manages hydroelectric operations to meet IGD targets.

4.3.2.3 *Fall/Winter Operations*

The fall/winter operational period extends from November 1 – February 28/29 for the Project and from October 1 – February 28/29 for the Klamath River (i.e., no EWA water is released after September 30). Note that there is often overlap between the spring/summer and fall/winter operations in October and November because Area A1 and the LKNWR will likely divert a portion of the spring/summer Project Supply during these months, while EWA accounting ends on October 1. Spring/summer and fall/winter diversion accounts must remain separate during the overlap period.

The fall/winter Project operational procedure distributes the available fall/winter UKL inflows among the following:

1. UKL:
    a. Increase UKL elevation to meet sucker habitat needs throughout the fall/winter period and the following spring/summer period, as well as increase storage for spring/summer EWA releases and irrigation deliveries.
    b. This is achieved through a fall/winter UKL refill rate and the UKL control logic.

2. Klamath River:

a. Release sufficient flow from IGD to meet ESA-listed species needs in the Klamath River downstream of IGD; this includes flows to support coho spawning from October 1 – November 15.
b. This is achieved through the formulaic approach to calculating IGD targets.

3. Project:
    a. KDD (Area A2 – served by North Canal and Ady Canal)
    b. Lease Lands in Area K (Area A2 – served by Ady Canal)
    c. LKNWR (Area A2 – served by Ady Canal)

Additionally, sufficient flood pool capacity must be maintained in UKL to balance refilling UKL to meet legal requirements with flood-related public safety issues. To satisfy these objectives, Reclamation proposes to calculate IGD target flows by means of a series of context-based real-time equations using the net UKL inflow as a hydrologic indicator.

Specific steps for calculating IGD target flows include:

1. Determine the LRD flow target, which is the maximum of either the minimum LRD flow target (look up table) or the LRD release target to support IGD target flows (calculated as follows)
    a. October 1 – November 15
        i. Determine the IGD target necessary for coho spawning flows
    b. November 16 – February 28/29
        i. Determine yesterday's smoothed UKL net inflow
        ii. Subtract 1.5 times the average daily UKL fill rate necessary to attain a UKL elevation of 4,143 feet on February 28/29
    c. Adjust based on the difference in UKL storage between the UKL adjusted central tendency and UKL elevation
    d. Constrain by the maximum LRD release capacity, if applicable

2. Determine the IGD flow target, which is the maximum of either the minimum IGD flow requirement or the IGD flow target (calculated below)
    a. October 1 – November 15
        i. Determine the IGD target necessary for coho spawning flows
    b. November 16 – February 28/29
        i. To the LRD flow target calculated in step 1, add LRD to Keno Dam accretions from 3 days prior (i.e., the accretion that occurred in a single day three days ago)
        ii. Add the value for today's Keno Dam to IGD accretions that was forecast 3 days ago (i.e., the accretion forecast for the current day that was issued three days ago)
        iii. Add KSD discharge (assumes 3-day lag)
        iv. Add the maximum of either LRDC flow towards the Klamath River minus diversion of LRDC water to North and Ady canals (assumes 3-day lag), or zero

Note that it is operationally possible to reduce LRD flows below the flow 'minimums' referred to above (further described in USBR 2018a Appendix 4 Section A.4.4.2), but this requires Reclamation to conduct a fish stranding assessment below LRD (and possibly below Keno Dam). This requires additional personnel and other resources, as well as being stressful to LRS, SNS, and other fish that may be in Link River during the reduction. Reclamation will weigh the benefit of flows below LRD minimums against the personnel, resource, and safety requirements necessary for completion of the stranding assessments. If a reduction below LRD "minimum" flows is desired, Reclamation will consult with USFWS and weigh the benefits against the costs described above. Additionally, note that the LRD target flow is not adjusted to account for the fill trajectory in UKL until November 16. October 1 through November 15 is a period of transition in Klamath Basin hydrology (i.e., UKL elevation transitions from decreasing to increasing), is a biologically sensitive time downstream of IGD (e.g., Chinook spawning and egg incubation) and is subject to highly variable accretions between LRD and IGD. Therefore, no adjustments beyond those of the UKL control logic are made to enhance UKL refill during this period.

Relative to fall/winter irrigation needs, up to 28,910 and 11,000 AF of fall/winter water is made available to KDD and LKNWR, respectively, subject to the UKL control logic. Specifically, if UKL elevation is at or above the adjusted central tendency throughout the fall/winter period, the only modeled constraints to delivery would be the delivery cap (28,910 and 11,000 AF for KDD and LKNWR, respectively), conveyance capacity, and demand. However, if UKL elevation is below the adjusted central tendency, daily deliveries to KDD and LKNWR will be reduced incrementally on a daily basis up to 80 percent. Fall/winter water available for delivery to KDD and LKNWR will be assessed every 5 days, when the ratio determining the delivery adjustment (termed the "storage difference ratio") is calculated. Similarly, LRD releases made for meeting IGD target flows can be reduced incrementally on a daily basis up to a maximum of 80 percent when UKL elevation is below the adjusted central tendency. Maximum reductions occur when UKL elevations approach the lower bound of the central tendency "envelope", the range of elevations within which the central tendency may fluctuate. Reductions to LRD releases due to UKL control logic cannot result in IGD releases below the IGD minimum flow requirements or exceed ramp rates specified in the 2019 BiOp (see USBR 2018a Appendix 4 Section A.4.4.1.1 for additional details).

It is possible to deviate from the fall/winter formulaic approach to calculating IGD flow targets. For instance, real-time hydrologic conditions, such as high flow events or emergency situations, or USGS rating curve adjustments may warrant the need to deviate from this formulaic approach. In addition, there may be specific ecological objectives that water resource managers may want to address that can only be achieved by deviating from the formulaic approach to calculating IGD targets. Any time a deviation from the formulaic approach occurs, either by necessity or to address a specific ecologic objective, or if it is determined that the formulaic approach results in conditions that are not consistent with the intent of the PA, the process detailed in Section 4.2.2.4 will be followed.

Finally, it is important to note that real-time hydrologic conditions will be closely monitored during the fall/winter to ensure that flood control elevations for UKL are not exceeded and adequate capacity remains in UKL to accommodate high runoff events, especially during rain-on-snow events. During high runoff events, deviations from the fall/winter management procedure may be required in order to protect public safety and the levees surrounding UKL. In addition, other unforeseen emergency and/or facility control issues could arise that would require deviations from the fall/winter management procedure. In such cases, Reclamation will return to the fall/winter management procedure as soon as the emergency or facility control issue is resolved, but Reclamation retains ultimate discretion regarding the timing of a return to the formulaic approach.

4.3.2.4 *Spring/Summer Operations*

The spring/summer operational period describes the second half of each water year and includes the irrigation season. The Project irrigation season is defined as March 1 – November 30 for Area A1 and March 1 – October 31 for Area A2.

The specific objectives during the spring/summer operational period include:

1. Provide irrigation deliveries to lands within the Project, including TLNWR and LKNWR, with a reasonable level of certainty; and

2. Maintain conditions in UKL and the Klamath River that meet legal requirements under section 7 of the ESA.

The irrigation season operations are controlled by defining the available UKL Supply, which is computed from end of February UKL storage, observed (since March 1) and forecasted monthly UKL inflows (March-September), and an end of September storage target. Division of this supply between the Klamath River (EWA) and Project (Project Supply; water available to the Project from UKL) is dependent on the size of UKL Supply. Any UKL inflow that is not delivered to the Project or released for Klamath River flows (EWA) will remain in UKL as storage. All water that leaves UKL through either LRD or the A Canal is accounted for against either EWA or the Project; this includes flood control releases (but does not include spill of UKL credit, which is the first volume of water to spill during flood control operations). Figure 4-1 illustrates how UKL Supply is divided amongst UKL, EWA and the Project. The schematic of spring/summer EWA, Project Supply, and volume remaining in UKL (i.e., the end of September storage target) is proportional to average volumes of water modeled over the POR. Project Supply includes both irrigation supply and LKNWR deliveries; this figure does not include LKNWR deliveries associated with transferred water rights.

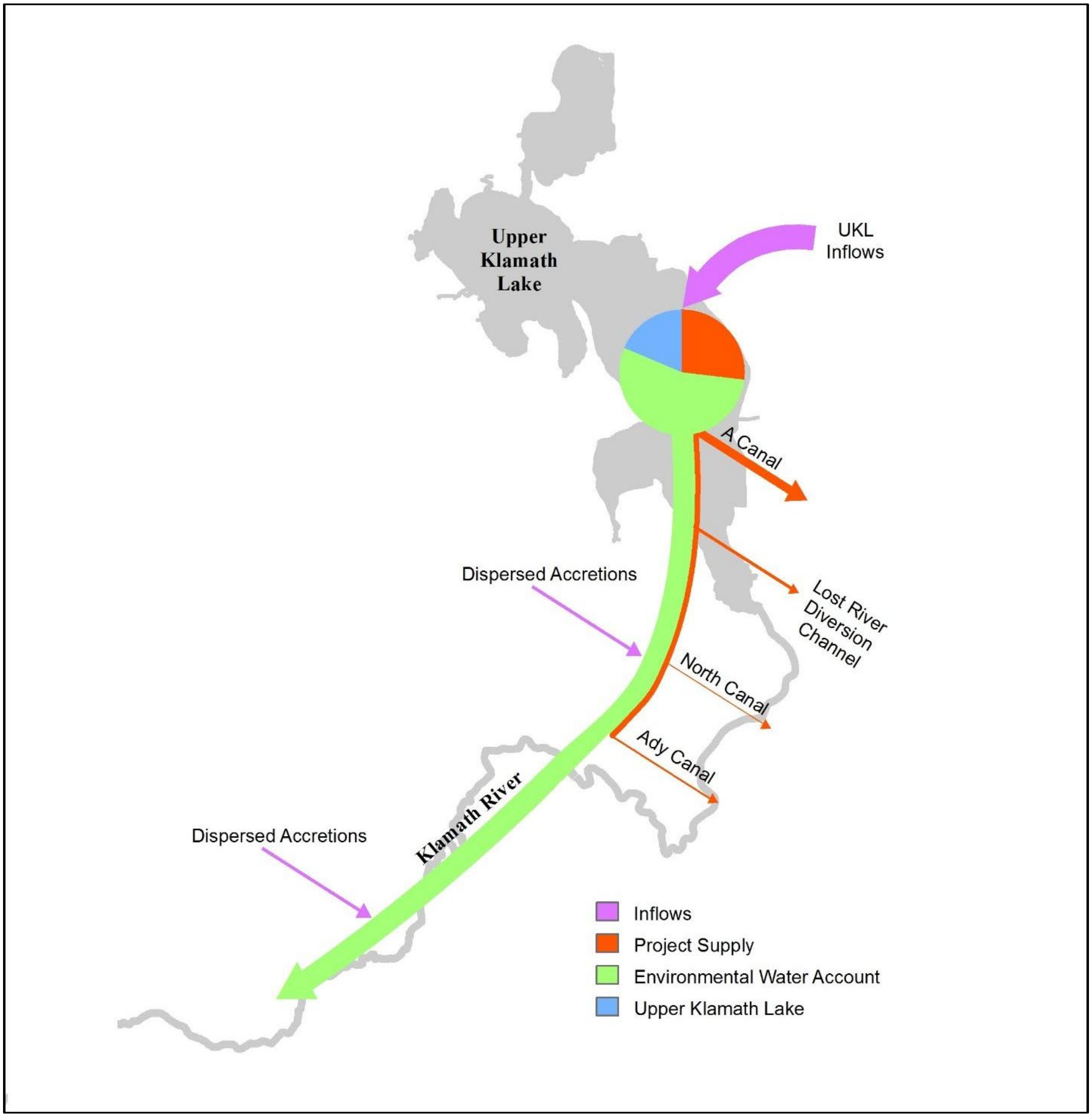


Figure 4-1. Division of UKL supply for spring/summer EWA, Project Supply, and volume remaining in UKL.

Throughout the spring/summer operational period, Reclamation will track EWA usage, daily and monthly reductions of IGD releases due to UKL control logic, Project deliveries, remaining Project Supply, UKL elevation relative to the adjusted central tendency, LKNWR deliveries, and the anticipated remaining LKNWR deliveries every 5 days and adjust releases as necessary to maintain operations consistent with this PA.

4.3.2.4.1 UKL Supply

UKL Supply is calculated on the first of each month (or when Reclamation receives the

NRCS UKL inflow forecast) from March – June. UKL Supply is calculated by adding the Mar50vol (50 percent exceedance volume of forecasted plus observed inflow) to the end of February UKL storage, and then subtracting the end of September UKL storage target. The specific steps for calculating UKL Supply and Mar50vol are detailed below.

First calculate the "Mar50vol," a combination of forecasted and observed March – September UKL inflow. For each month, Mar50vol is calculated as follows:

1. March 1
    a. Equal to the March 1 NRCS 50 percent exceedance March – September UKL inflow forecast

2. April 1
    a. April 1 NRCS 50 percent exceedance April – September UKL inflow forecast, plus
    b. Measured March net inflows

3. May 1
    a. May 1 NRCS 50 percent exceedance May – September UKL inflow forecast, plus
    b. Measured March net inflows, plus
    c. Measured April net inflows

4. June 1
    a. June 1 NRCS 50 percent exceedance June – September UKL inflow forecast, plus
    b. Measured March net inflows, plus
    c. Measured April net inflows, plus
    d. Measured May net inflows

Next, calculate the end of September UKL storage target. This target is dependent on the default end of September UKL central tendency elevation (4,139.1 feet), the end of September "envelope" around the UKL central tendency (+/- 0.4 feet), and the Mar50vol. The purpose of the end of September UKL storage target in determining UKL Supply is to constrain the amount of UKL storage used in a given year. Such constraint is necessary to balance near-term demand for irrigation diversion or river flow with the uncertainties associated with future hydrologic conditions. Note that the end of September UKL storage target is a mathematical term (and the name of this model variable is a legacy of the 2012 BA) and is not a management target. It is effective in "constraining" use of UKL storage since it is not mathematically allocated to EWA or Project Supply during the March 1 – June 1 spring/summer supply calculations.

4.3.2.4.2 Project Supply

As in the 2012 BA/ 2013 BiOp, Project Supply is calculated on the first of each month from March – June, after volumes have been set aside for coho (EWA) and suckers (end of September target). To provide early-season certainty for Project irrigators, the calculated April 1 Project Supply is "locked in" such that Project Supply may go up as a result of increased NRCS UKL inflow forecasts on May 1 and June 1 but cannot drop below the April 1 calculation. In the event that the NRCS inflow forecasts are substantially lower in May and June, relative to the April forecast, UKL storage volume will be utilized to deliver the "locked-in" April 1 Project Supply. The UKL Credit was specifically designed to help offset any negative effects to UKL storage and listed suckers (by increasing UKL elevation above what it otherwise would have been) potentially resulting from this scenario. Further, because UKL storage is utilized to offset NRCS forecast error, there is no direct effect on EWA calculations in a given water year.

Maximum Project Supply is 350,000 AF, which occurs when UKL Supply is greater than 1,035,000 AF (which occurs in 30 percent of simulated years). When UKL Supply is less than 1,035,000 AF, Project Supply is equal to UKL Supply minus EWA except in years in which April 1 EWA is greater than 400,000 AF (407,000 AF in Boat Dance years) and less than 576,000 AF. In these years, April 1 Project Supply is reduced by 10,000 AF (*see* Section 4.2.2.3). The final determination for Project Supply is made in June and is then fixed through the end of September. It is important to note that delivery of the "fixed" Project Supply is not guaranteed; Reclamation retains discretion to curtail deliveries from UKL to comply with legal requirements and hydrologic conditions as necessary. Finally, the UKL control logic does not directly affect spring/summer Project deliveries, except delivery of Project Supply to LKNWR in the August – November period (which can be decreased by as much as 50 percent based on the UKL control logic).

Project Supply is only the supply of water to be made available to the Project and LKNWR from UKL and does not take into account diversions of discharge in the LRDC and return flows from the KSD. In other words, any water diverted from the LRDC or KSD for irrigation does not count against the Project Supply from UKL. Since only the water originating from UKL counts towards the Project Supply, Project diversions of LRDC discharge and KSD return flows will be evaluated daily and subtracted from the total Project diversion to compute the daily Project Supply usage. It is important to note that the KBPM utilizes perfect foresight to ensure that all of the Project Supply and all return flows that are needed to meet Project demand are diverted in full. As discussed above, any portion of LRDC or KSD return flows not diverted by the Project (that directly support IGD targets and result in a reduction in LRD releases) accrue as UKL Credit that remains in UKL to buffer against NRCS inflow forecast error.

In order to realistically distribute Project Supply over the irrigation period in the KBPM, which is critical in evaluating the effects of Project operations on listed species at specific times of the spring/summer period, Reclamation developed an Agricultural Water Delivery sub-model. The Agricultural Water Delivery sub-model simulated delivery of irrigation water on a 5-day time-step based on variables such as meteorological conditions, soil moisture, water availability, and deliveries in the previous 5-day timestep, scaled to Project Supply. To ensure that the sub- model would adequately simulate Project deliveries under this PA, the sub-model was first tested against historical Project deliveries and performed relatively well. This sub-model is a substantial improvement over past representations of agricultural deliveries in the KBPM.

Finally, Reclamation proposes to deliver Project Supply to LKNWR (not inclusive of Area K [Project Lease Lands served by Ady Canal which are served out of Project Supply]) in the spring/summer operational period. Proposed spring/summer LKNWR deliveries are likely to include a combination of water available from Project Supply and stored water from UKL available in wet years, as further described below.

Reclamation, and USFWS, in coordination with Project irrigators and other stakeholders, are currently undertaking a process to identify the relative priority of lands within LKNWR to available Project water, and to develop a shortage sharing agreement to address delivery shortages to LKNWR (Connor 2017). As that process is still on-going, the outcome from this process is not included in Reclamation's PA. However, because any volume identified for delivery to LKNWR through that process will not increase Project Supply (which is already modeled as coming from UKL in the KBPM), Reclamation has concluded that the distribution of Project Supply will generally remain consistent with the simulated distribution pattern and magnitude and will not alter the effects of Project operations on ESA-listed species described herein. In other words, if in the future a shortage sharing agreement is finalized and deliveries to LKNWR are part of Project Supply, the effects of that delivery to listed species should be no different than under the PA analyzed in this BA and therefore reinitiation of consultation should not be required under 50 CFR 402.16(a) or (c).

Until the process described above is complete, Reclamation proposes to coordinate with USFWS and other Project water users to determine when Project Supply during the spring/summer operational period can be made available to LKNWR consistent with Reclamation's and delivery agencies' contractual and other legal obligations. When Reclamation determines that there is Project Supply not needed to meet other Project demands, such water can be delivered to LKNWR, as the model assumes delivery of the full Project Supply allocation in all years.
In addition to a portion of Project Supply, LKNWR may also receive spring/summer deliveries in June and July if Project Supply is 350,000 AF and UKL elevations are above 4,142.5 and 4,141.5 feet, respectively, on the first of each month; daily values to be exceeded are linearly interpolated thereafter. When these conditions were met in the modeled POR (11 of the 36 years), a maximum of 3,000 AF was made available to LKNWR from this source. Note that this water is not considered Project Supply.

4.3.2.4.3 Environmental Water Account

Similar to IGD flow targets in the fall/winter period, EWA (the volume of water used to meet IGD flow targets in spring/summer) distribution is based on a spring/summer formulaic approach for calculating IGD flow targets. The spring/summer formulaic approach is based on the EWA allocation, UKL control logic, UKL net inflow, and NRCS-forecasted March – September net inflow (50 percent exceedance) from March 1 – June 30. From March 1 – June 30 there is also a correction applied that accelerates EWA release if there was under-release in previous days (e.g., due to UKL control) and decelerates EWA release if there was an over-release in previous days (e.g., due to flood control, disease mitigation, or habitat flows). From July 1 – September 30, EWA distribution is based on remaining EWA and UKL control logic. EWA releases for disease mitigation/habitat flows, minimum required IGD flows, and IGD ramping flows are not subject to reduction under UKL control logic at any time. Finally, KSD return flows are no longer considered accretions that EWA releases rely on, which is a change from the 2013 BiOp. In the spring/summer, any return flows from LRDC and KSD not used by the Project contribute to the UKL Credit during controlled flow conditions when LRD releases are above the minimum flow targets.

The specific steps for calculating IGD target flows in the spring/summer include:

1. Determine the LRD flow target as follows:
    a. March 1 – June 30
        i. Determine the release adjustment factor (termed "in_pct_Mar50vol") that combines observed and forecasted net inflow, NRCS forecast error, and UKL Supply.
        ii. Multiply by the calculated EWA allocation, minus the 130,000 AF EWA volume reserved for the July to September baseflow period (137,000 AF in Boat Dance years), minus the release correction that accounts for the difference between the previous day's actual and calculated LRD releases (termed "Link_release_ss_diff").
    b. July 1 – September 30
        i. Divide the volume of EWA remaining for the current month by the number of days in the current month.
    c. Adjust based on the difference in UKL storage between the UKL adjusted central tendency and UKL elevation.
    d. Constrain by the maximum LRD release capacity, if applicable.

2. Determine the IGD flow target, which is the minimum of either the maximum IGD flow (look up table) or the IGD flow target.
    a. To the LRD flow target calculated in step 1, add LRD to Keno Dam accretions from three days prior (i.e., this step relies on the accretion that occurred in a single day three days ago).
    b. Add today's forecasted Keno Dam to IGD accretions from three days prior (i.e., this step relies on the accretion forecast for the current day that was issued three days ago).
    c. Increase to the minimum IGD flow requirement, if applicable.

The EWA volume is calculated on the first of each month from March – June as a portion of UKL Supply. Minimum EWA is 400,000 AF (407,000 AF in Boat Dance years), which occurs when UKL Supply is less than 660,000 AF. When UKL Supply is greater than 1,035,000 AF, EWA is calculated as UKL Supply minus the maximum Project Supply (350,000 AF). When UKL Supply is between 660,000 AF and 1,035,000 AF, EWA is calculated as a percentage of the UKL Supply. Note that EWA is increased by 7,000 AF in even years to augment IGD releases for the Yurok Boat Dance ceremony, typically occurring in late August or early September. Additionally, 20,000 AF is added to May and June IGD targets in years with April 1 EWA greater than 400,000 AF (407,000 AF in Boat Dance years) and less than 576,000 AF. The EWA volume calculated from the June 1 UKL inflow forecast is the final EWA volume for the year, with the exception of years with enhanced May/June flows in which July 1 EWA is supplemented with 20,000 AF. It is possible that the spring/summer formulaic approach to calculating IGD targets described above will result in an "overspend" (i.e., formulaic approach required more volume than was calculated for EWA, particularly if the Klamath River is at minimums) or an "underspend" (i.e., formulaic approach required less volume than was calculated for EWA) between March 1 - September 30. Regardless of the calculated EWA volume, IGD releases will reflect calculated IGD targets, with the exception of implementation of surface flushing flows and enhanced May/June flows. If EWA is overspent, UKL storage will be utilized to continue meeting IGD targets through September 30. If EWA is underspent, the unused EWA volume remaining on September 30 will remain in UKL. There is no inter-annual carryover of EWA.

The EWA is accounted for by LRD releases for the Klamath River and flood control releases. In other words, all LRD releases between March 1 and September 30 that are not diverted to the Project and/or LKNWR through LRDC or North and Ady Canals, are a component of the EWA. Conversely, all stored water and live flow that is diverted at the A Canal or released from UKL via LRD and diverted at the LRDC, North Canal, and Ady Canal during the spring/summer period are a component of the Project Supply. Measurements for these diversions will be obtained at the point of diversion or measured at the location identified by the state of Oregon in the Amended and Corrected Findings of Fact and Order of Determination (ACFFOD). For the measurement of these diversions below LRD, the UKL contribution will be the overall measurement less any flows from the LRDC and KSD.

Additionally, during controlled flow conditions (i.e., not during flood control operations), LRDC and KSD flows are counted against EWA when LRDC and KSD discharges (in excess of direct diversions for irrigation) are utilized to meet IGD flow targets, enabling LRD releases to be reduced. The volume of discharge counted against the EWA is equivalent to the volumetric reduction in LRD releases that occur due to utilization of LRDC and KSD flows to meet IGD flow targets.

Flood control releases and LRD releases above minimums for the Klamath River made between March 1 and September 30 are a component of the EWA. However, releases made during March through June could potentially be large enough that the remaining EWA volume would not be considered adequate to provide acceptable fish habitat for the July through September period. In order to ensure that sufficient EWA volume remains, EWA volume may need to be reset to a higher volume to account for high expenditures during March through June. When LRD releases for EWA purposes are above LRD minimums, the volume released above LRD minimums are tracked cumulatively from March through September. If this cumulative volume exceeds 22 percent of total EWA for July 1 to the end of September, Reclamation provides a protective increase in EWA to support implementation of formulaic IGD flows. This EWA volume protection is applied on a monthly basis from July through September. Remaining EWA volume may exceed the increased EWA volume, in which case the larger of the two EWA volumes is utilized to calculate future IGD releases (see USBR 2018a Appendix 4 Section A.4.4.8 for specific details).

As with fall/winter operations, close coordination and communication between Reclamation and PacifiCorp on the operation of the Klamath Hydroelectric Project will be required to efficiently implement any EWA flow schedule. PacifiCorp will implement releases downstream of IGD based on target flows provided by Reclamation. Reclamation will calculate those target flows according to the EWA distribution formula starting on March 1 of each year, with the exception of surface flushing flows and May/June flows when additional volume will be added to the IGD targets. Once implementation of the formulaic approach for EWA distribution is initiated, Reclamation will monitor IGD flows to ensure that the actual observed flows are consistent with the EWA flow schedule (see Section 4.2.2.5 for additional information regarding coordination with PacifiCorp).

As described above, EWA distribution will follow the spring/summer formulaic approach for calculating IGD target flows. However, it is possible to deviate from the spring/summer formulaic approach to EWA distribution. Specifically, real-time hydrologic conditions, such as high flow events or emergency situations, may warrant the need to deviate from this formulaic approach. In addition, there may be specific ecologic objectives that water resource managers may want to address that can only be achieved by deviating from the formulaic approach to EWA distribution. Any time a deviation from the formulaic approach occurs, either by necessity or to address a specific ecologic objective, or if it is determined that the formulaic approach results in conditions that are not consistent with the intent of the PA, the process detailed in Section 4.2.2.4 will be followed. However, the formulaic approach for EWA distribution considered in this PA was designed to meet the key ecologic objectives for UKL and the Klamath River. Therefore, Reclamation anticipates that implementation of the formulaic approach will address these ecologic objectives, and frequent deviations from this approach are not expected to be necessary, aside from those anticipated for disease mitigation/habitat flows.

4.3.2.4.4 Disease Mitigation and Habitat Flows

Reclamation proposes to deliver the EWA based on the formulaic approach described above. However, the PA provides flexibility to deviate in real-time from the formulaic approach in the spring/summer operational period to deliver:

1. Approximately 50,000 AF of EWA in a manner that best meets coho needs (i.e., disease mitigation, habitat, etc.) in below average to dry years or

2. An "opportunistic" surface flushing flow in average to average to wet years if hydrologic conditions allow.

Reclamation has modeled use of the approximately 50,000 AF of EWA in below average to dry years as a disease mitigation flow, specifically a surface flushing flow. Surface flushing flows in the KBPM reflect those described as Disease Management Guidance #1 in the

Disease Management Guidance document (Hillemeier et al. 2017 pp. 8–10) and constitutes a release of at least 6,030 cfs from IGD for at least 72 consecutive hours. The specific objective of the surface flushing flows is to disturb surface sediment along the river bottom and disrupt the life cycle of *Manayunkia speciosa* (a polychaete), which is a secondary host for the *Ceratonova shasta* parasite central to salmonid disease dynamics in the Klamath River.

Additionally, implementation of approximately 50,000 AF of EWA described above must not result in impacts to suckers in UKL outside of those analyzed by USFWS; if Reclamation believes implementation of this volume may result in impacts to suckers outside of those analyzed by USFWS, Reclamation will coordinate with the Services.

4.3.2.4.4.1 Below Average to Dry Years (March 1 and/or April 1 EWA less than 576,000 AF)

As part of the PA, approximately 50,000 AF of EWA was modeled as available to meet coho needs in the form of a "forced" surface flushing flow, as requested by National Marine Fisheries Service (NMFS). The Tri-Agency Hydro Team agreed to model this volume of water as a surface flushing flow in the KBPM. These assumptions do not limit NMFS's ability to request implementation of this volume in a different manner or request that Reclamation utilize this volume only for a surface flushing flow. Reclamation has not attempted to develop implementation criteria for other potential uses of the approximately 50,000 AF. However, Reclamation is proposing that the following criteria be utilized if a surface flushing flow is determined by NMFS to be the appropriate use of the approximate 50,000 AF. Additionally, note that Reclamation will allow for flexibility in the timing of the flushing flow in order to maximize benefit to coho salmon and minimize impact to suckers in UKL. This may include delaying a flushing flow, despite the criteria listed below being met in full, to take advantage of favorable hydrologic conditions. These actions will be taken in consultation with the Services and should not produce impacts to any listed species or resource beyond what is considered in the scope of this action.

Specific criteria for implementing a forced surface flushing flow include all the following:

1. Date is between March 1 and April 15;

2. March 1 and/or April 1 EWA is less than 576,000 AF;

    a. If March 1 EWA and April 1 EWA are less than 576,000 AF, a forced surface flushing flow will be implemented between March 1 and April 15

    b. If March 1 EWA is greater than or equal to 576,000 AF, but April 1 EWA is less than 576,000 AF, a forced surface flushing flow will be implemented between April 1 and April 15

    c. If March 1 EWA is less than 576,000 AF and April 1 EWA is greater than or equal to 576,000 AF, a forced surface flushing flow will be implemented in

March. However, if Reclamation, NMFS and USFWS determine that delaying the release until after March 31 minimizes impacts to UKL and listed suckers, optimizes EWA efficiency, and maximizes benefits to coho salmon, then the surface flushing flow will be implemented between April 1 and April 15

3. There is sufficient head behind LRD to produce 6,030 cfs for 72 hours at IGD; and

4. The previous day's UKL elevation is greater than or equal to 4,142.4 feet.

If a flushing flow has not been implemented by April 15, a flushing flow (maximum discharge possible, up to 6,030 cfs, released for 72 hours) is attempted regardless of UKL elevation, maximum LRD capacity, or IGD flow.

4.3.2.4.4.2 Average to Wet Years (March 1 and April 1 EWA greater than or equal to 576,000 AF)

Reclamation proposes implementation of an opportunistic surface flushing flow in average/wet years.

Specific criteria for implementing an opportunistic surface flushing flow include all of the following:

1. Date is between March 1 and April 15;

2. March 1 and April 1 EWA greater than or equal to 576,000 AF;

3. There is sufficient head behind LRD, and accretions between LRD and IGD, to produce 6,030 cfs for 72 hours at IGD;

4. The previous day's UKL elevation is greater than or equal to 4,142.4 feet; and

5. The previous day's IGD flow is greater than or equal to 3,999 cfs.

4.3.2.4.4.3 Surface Flushing Flow Accounting Details

Surface flushing flows adhere to the rules outlined below and are subject to ramping rates outlined in Section 4.3.2.2.5.

1. All flows that meet the KBPM criteria for a surface flushing flow, but occur outside of the March 1 to April 15 window, are not considered a surface flushing flow by the KBPM.

2. All surface flushing flows that meet the KBPM criteria for a surface flushing flow are counted against the EWA.

3. Surface flushing flows are not subject to reductions under UKL control logic.

4. Surface flushing flows (as are all flows), are subject to ramping rates outlined in Section 4.2.2.3.

5. Generally, all flows that are initiated or released outside of the March 1 to September 30 window do not count against the EWA, whereas all flows initiated or released from March 1 to September 30 are counted against the EWA.

Implementation of these rules in KBPM has resulted in a surface flushing flow (at least 6,030 cfs from IGD for at least 72 consecutive hours), described as Disease Management Guidance #1 (Hillemeier et al. 2017 pp. 8–10), in 35 out of 36 years modeled. The only year where the surface flushing flow was attempted but not achieved was 1992, one of the driest years in the POR. An average flow of 4,233 cfs for 72 hours was all that could be achieved due to insufficient head in UKL behind LRD (see USBR 2018a Appendix 4 Section A.4.4.7 for additional information regarding implementation of surface flushing flows in the KBPM).

4.3.2.4.4.4 Deep Flushing Flows

Reclamation has not explicitly modeled a deep-flushing flow (11,250 cfs for 24 hours), described as Disease Management Guidance #2 in the Disease Management Guidance document (Hillemeier et al. 2017 pp. 10–11). However, Reclamation will attempt to implement deep flushing flows when hydrologic conditions and public safety allow. Specifically, infrastructure limitations and public safety issues (particularly release capacity at LRD and flood concerns in the middle and lower Klamath Basin) are such that a suite of conditions must be present in order to implement a flow of sufficient magnitude to accomplish the objectives of a deep flushing event. These conditions include, but are not limited to, UKL storage to allow for sufficient LRD release capacity, UKL storage sufficient to protect sucker needs, substantial accretions, and Klamath River tributary discharge that does not result in public safety and property concerns. Typically, this suite of conditions occurs when UKL is at flood curve in the late winter or early spring and there is a rain-on-snow hydrologic event. Maximum LRD capacity at the maximum allowable UKL elevation under the current flood curve (4,143.3 feet) is approximately 8,600 cfs, meaning that additional accretions of up to approximately 2,650 cfs for 24 hours would be necessary to achieve 11,250 cfs from IGD at full UKL storage under this PA; accordingly, larger accretions are necessary if UKL elevation is less than 4,143.3 feet. Implementation of a deep flushing flow will require coordination with PacifiCorp and numerous public safety entities.

KBPM output indicates that implementation of the PA results in achieving a deep flushing flow (11,250 cfs for 24 hours) in 4 out of the 36 years in the POR. Deep flushing flows were implemented in water years 1982, 1986, 1996 and 1997. Implementation of the PA results in zero deep flushing flows implemented for 19 consecutive years from 1998 through 2016, although in 2006, a flow of 10,124 cfs for 24 hours was achieved.

4.3.2.4.4.5 Enhanced May/June Flows

In years in which April 1 EWA is greater than 400,000 AF (407,000 AF in Boat Dance years) and less than 576,000 AF, an additional 20,000 AF (10,000 AF from Project Supply and the balance from a combination of live flow and UKL) is distributed in May and June. This action is meant to improve coho habitat quantity and quality in specific years of concern to NMFS. NMFS has requested flexibility in the distribution of the 20,000 AF to maximize the benefit to listed coho, while maintaining UKL elevations/conditions necessary for listed suckers. However, for purposes of modeling effects of the enhanced May/June flows and Reclamation's planning needs, unless NMFS requests alternative management scenarios in a given water year, the specific "default" rules for implementing this 20,000 AF for enhanced May/June flows are as follows:

1. April 1 EWA is greater than 400,000 AF (407,000 AF in even years) and less than 576,000 AF;

2. Daily calculated May IGD flow targets are increased by 195 cfs (12,000 AF total in May);

3. Daily calculated June IGD flow targets are increased by 134 cfs (8,000 AF total in June); and

4. April 1, May 1, and June 1 Project Supply estimates are reduced by 10,000 AF.

Note that because the 20,000 AF for enhanced May/June flows was counted against EWA (when it should be in addition to EWA), 20,000 AF is added to the July 1 EWA to ensure proper EWA accounting for the remainder of the spring/summer season. Additionally, the default rules assume that when enhanced May/June flows are implemented and IGD flow targets would otherwise be at minimums, Reclamation would implement flow variability (up to +/- 75 cfs around enhanced IGD flow targets).

Implementation of enhanced May/June flows as described above must not result in impacts to suckers in UKL outside of those analyzed in this document; if Reclamation determines that implementation of these flows may result in impacts to suckers outside of those analyzed here, Reclamation will coordinate with USFWS.

Reclamation anticipates NMFS will recommend alternative distributions to default rules 2 and 3 described above, based on information specific to environmental conditions and forecasts as a means to optimize the benefit to coho salmon. Reclamation, in coordination with the Services, will ensure that these alternative distributions will not result in greater impact to listed suckers than those considered in this document (*see* Section 7 for effects to listed suckers).

NMFS will lead annual efforts to evaluate and seek input from the Flow Account Scheduling Technical Advisory (FASTA) Team members (see below for details regarding FASTA) on alternatives to deviate from default criteria used to implement both the May/June 20,000 AF volume and 50,000 AF volume for surface flushing flow. *See* Section 4.2.2.5 for additional details regarding the process to assist in determining the appropriate use of the 20,000 AF in years in which April 1 EWA is greater than 400,000 AF (407,000 AF in even years) and less than 576,000 AF. Ultimately, Reclamation retains discretion and authority for flow management decisions.

4.3.2.5 *Flow Ramping at Iron Gate Dam*

Ramping rates limit rapid fluctuations in streamflow downstream of dams. Reclamation proposes a ramping rate structure that varies by release rate at IGD. The ramp rates proposed below are as measured at the USGS gaging station located immediately downstream of IGD (USGS Station ID#: 11516530). IGD is owned and operated by PacifiCorp and the ramp down rates will be implemented by PacifiCorp as part of IGD operations.

The target ramp down rates at IGD, when possible, are as follows:

- When IGD flows are greater than 4,600 cfs: decreases in flows of no more than 2,000 cfs per 24-hour period, and no more than 500 cfs per 6-hour period.

- When IGD flows are greater than 3,600 cfs but equal to or less than 4,600 cfs: decreases in flows of 1,000 cfs or less per 24-hour period, and no more than 250 cfs per 6-hour period.

- When IGD flows are greater than 3,000 cfs but equal to or less than 3,600 cfs: decreases in flows of 600 cfs or less per 24-hour period, and no more than 150 cfs per 6-hour period.

- When IGD flows are above 1,750 cfs but equal to or less than 3,000 cfs: decreases in flows of 300 cfs or less per 24-hour period, and no more than 125 cfs per four-hour period. (Note that ramp rates can be slower, such as 75 cfs per 6-hour period, if Reclamation and PacifiCorp agree on a schedule).

- When IGD flows are 1,750 cfs or less: decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per 2-hour period.

- Upward ramping is not restricted.

Facility control limitations and stream gage measurement error may limit the ability to precisely manage changes in releases from IGD. 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 (within 10 percent of targets) will occur for short durations and all ramping rates proposed above are targets. Reclamation foresees the possibility of exceedance of the proposed ramp rates due to facility control limitations, stream gage error, and/or emergency situations that will occur infrequently and will be corrected as soon as possible if they do occur.

NMFS acknowledges that the ramp rates are targets and will be followed by PacifiCorp to the greatest extent practicable. Iron Gate powerhouse has a maximum hydraulic capacity of approximately 1,750 cfs, and Iron Gate dam has only an overflow spillway. At IGD flows above

1,750 cfs, all flows downstream of Iron Gate dam are managed by releases from upstream Copco No. 1 and Copco No. 2 developments. Copco releases are imprecise because flow is measured in megawatt generation, not cubic-feet per second (cfs). NMFS also acknowledges that there are wind effects on Iron Gate reservoir and changing accretions, in addition to considerable travel time between Copco and Iron Gate dam that can result in imprecise flow releases and ramp rates at IGD.

Under some circumstances (based on presence and abundance of ESA-listed species, life cycle stage, hydrologic conditions in the Klamath River and tributaries, and other considerations) the proposed ramp rates may be more stringent than necessary to prevent the stranding of ESA-listed species downstream of IGD. Reclamation, in coordination with NMFS, may explore more flexible ramping rates to determine under what conditions those rates would be appropriate to implement.

IGD is a PacifiCorp facility and Reclamation does not have control over the implementation of ramp rates and operations at IGD. However, Reclamation will coordinate with PacifiCorp as appropriate to ensure that implementation of the ramp down rates is consistent with those proposed herein and required by PacifiCorp's Interim Operation Habitat Conservation Plan for Coho Salmon (HCP; PacifiCorp 2013).

4.3.2.6 *Flow Account Scheduling Technical Advisory (FASTA) Team and the Flow Management Process*

There may be opportunities to benefit coho through deviations from the formulaic approach to IGD targets in the fall/winter and EWA distribution in the spring/summer. Additionally, NMFS has recommended that Reclamation retain flexibility in shaping approximately 50,000 AF of EWA in years with March 1 and/or April 1 EWA volumes less than 576,000 AF and 20,000 AF for May/June habitat flows in years with April 1 EWA volumes greater than 400,000 AF (407,000 AF in Boat Dance years) and less than 576,000 AF. Reclamation, in coordination with the Services, will consider input from Klamath Basin technical experts relative to these actions and opportunities. Reclamation therefore proposes that the Flow Account Scheduling Technical Advisory (FASTA) Team be the venue in which these technical experts provide input on flow management options.

The primary purpose of the FASTA Team is to share information on hydrologic, meteorological, disease, and other conditions among Klamath Basin technical experts. However, an important secondary function will be to serve as a venue for input on flow management options, including input or evaluations regarding the shaping of approximately 50,000 AF of EWA for disease mitigation or habitat improvement/protection in years with March 1 or April 1 EWA volumes less than 576,000 AF. Participants in the FASTA Team are technical specialists focused on meaningful participation facilitating timely implementation of the flow input process and providing input to Reclamation and the Services. Operational or compliance decisions will not be made by the FASTA Team or during FASTA Team calls or meetings.

Reclamation retains decision-making authority relative to flow management and operations on and related to the Project, though Reclamation encourages input and feedback from the FASTA Team. Reclamation also retains discretion regarding FASTA Team participants.

Ultimately, Reclamation, acting under the authority of the Secretary of the Interior, makes flow management decisions affecting UKL and the Klamath River; the process outlined in this section does not relinquish this Secretarial responsibility. Additionally, Reclamation determines whether proposed flows are consistent with flood control, public safety, and operational constraints for UKL and the Klamath Project.

The specific process for providing flow management input via the FASTA Team is as follows:

1. A FASTA Team member (inclusive of the Services) provides input regarding flow management during a FASTA Team call, or via email or call directly to the Klamath River Manager.
   a. If the input is provided outside of a FASTA Team call, the Klamath River Manager may choose to schedule a call or otherwise discuss the input with other FASTA Team members prior to moving to step two.

2. The Klamath River Manager initiates internal Reclamation discussions to determine if the proposed flows are operationally feasible. Specifically, this will include evaluating whether:

   a. The proposed flows are feasible given Reclamation infrastructure and operations, public safety, flood control, and other operational constraints;

   b. The proposed flows comply with applicable state and Federal law; and

   c. The proposed flows are consistent with the PA.

   d. If the proposed flows are determined by Reclamation to not be operationally feasible for the Klamath Project, no further action is necessary.

3. If Reclamation determines the proposed flows are operationally feasible, Reclamation will initiate conversations with PacifiCorp to determine if the proposed flows are operationally feasible for PacifiCorp's Klamath Hydroelectric Project.

   a. If the proposed flows are determined by Reclamation and/or PacifiCorp to not be operationally feasible, no further action is necessary.

4. If the proposed flows are operationally feasible for both Reclamation and PacifiCorp,

Reclamation will initiate conversations with the Services to determine if the proposed flows provide additional ecological benefit to coho salmon while maintaining UKL elevations/conditions necessary for listed suckers.

a. If the proposed flows are determined by Reclamation and/or Services to not provide additional ecological benefit, no further action is necessary.

5. If the Services determine that the proposed flows are likely to result in benefit to coho salmon and would not adversely affect listed suckers, then Reclamation will take steps to implement the proposed flows. Reclamation will be responsible for implementing the proposed flows, coordinating with PacifiCorp, issuing public safety notices, and any other coordination required to implement in a timely manner.

Reclamation retains discretion to deviate from the steps outlined above when considering flow management input. Additionally, Reclamation will communicate with FASTA Team members the outcome of the steps above, when possible and appropriate. Also note that Reclamation retains discretion to end FASTA calls if participants other than technical experts are on the call.

Finally, the Klamath River Manager is the individual responsible for scheduling and holding FASTA Team calls (as needed, but typically weekly or every other week) and distributing relevant information (as needed, but typically weekly, typically in the form of a slide presentation). Weekly updates will typically include information such as EWA use, remaining EWA, Project deliveries, remaining Project Supply, UKL elevation, LKNWR deliveries, projected IGD target flows, NRCS forecasts, meteorological information, etc. Reclamation retains discretion regarding the content of the FASTA slides and any other information made available to the FASTA Team, and the timing and frequency of FASTA Team calls.

4.3.2.7 *Tule Lake Sump Operations*

The proposed minimum elevations for Tule Lake Sump 1A are described below. Tule Lake National Wildlife Refuge (TLNWR) deliveries are outlined in Section 4.2.2.6. Actual water availability and TID return flows will determine the amount of water available for TLNWR including federal lease lands. Reclamation proposes to maintain a consistent annual minimum elevation in Tule Lake Sump 1A (Table 4-3).

During excessively dry periods when the UKL Supply is inadequate to meet Project demands, it may not be possible to maintain Tule Lake Sump 1A elevations due to decreased runoff to Tule Lake Sump 1A. This condition would be outside of Reclamation's control and the proposed minimum elevations would not apply. In the event that surface water supply is estimated to be unavailable or is insufficient to maintain biological minimum elevations of Tule Lake Sump 1A (e.g., greater than 95 percent exceedance inflow years such as 1992 and 1994), Reclamation proposes to coordinate with USFWS as early as is possible to determine if relocation of adult suckers from the sumps to more permanent bodies of water within the species range is prudent.

Table 4-3. Minimum Sump 1A Elevations (Reclamation Datum).

Time Period	Elevation (feet)
April 1 through September 30 (each year)	4,034.0
October 1 through March 31 (each year)	4,034.0

During dry winter conditions, Reclamation will initiate discussions with USFWS to determine the best course of action, including the likelihood of a sucker relocation effort from Tule Lake. If Reclamation and USFWS deem it necessary to relocate suckers from Tule Lake during these discussions, Reclamation, in coordination with the USFWS, will develop a proposal that Reclamation will employ to relocate suckers from the Tule Lake Sumps before seasonally stressful conditions develop. The proposal will describe methods for capture and transport of fish, release sites, fish handling techniques, and the appropriate level of effort expected to relocate suckers.

4.3.2.8 *Other Refuge Deliveries*

Federally-owned lands within TLNWR and LKNWR receive and use Project water from multiple sources, in a variety of ways as described below.

For TLNWR, irrigated agricultural lands generally obtain water for irrigation and refuge use from return flows from irrigated lands within the Project. These return flows accumulate in the Tule Lake Sumps and are diverted via the R and Q canals or are pumped into the N Canal from drains serving private lands in TID.

Generally, irrigation return flows and tributary runoff are adequate to meet irrigation and Refuge demands within TLNWR, limiting the need for direct deliveries from UKL and the Klamath River. When irrigation demands are high, Project Supply during the spring/summer period (i.e., water from UKL and the Klamath River) may be needed for irrigation use within TLNWR. All deliveries to TLNWR are coordinated between TID and USFWS, Reclamation, or the individual lessee of the lands, consistent with Reclamation's water supply contract with TID.

LKNWR deliveries proposed as part of this PA are discussed in Sections 4.2.2.2 and 4.2.2.3 above. In addition to the proposed fall/winter and spring/summer deliveries, Reclamation also anticipates that from April 1 – September 30 LKNWR will exercise a water right temporarily transferred from the Agency Lake and Barnes Ranch properties to irrigable lands in LKNWR. In the State of Oregon, a valid water right, such as those appurtenant to the

Agency Lake and Barnes Ranch properties, can be exercised at any time for the authorized beneficial purpose within the authorized period of use, to the extent water is physically available at the point or points of diversion and the water right is not otherwise subject to regulation based on a call by a senior water rights holder.

Collectively, the transferred water right from the Agency Lake and Barnes Ranch properties allows for diversions at the Ady Canal of up to approximately 31 cfs and 11,200 AF in total annually. This transferred water right has a priority date of September 13, 1920 and is potentially subject to water rights regulation in the Upper Klamath Basin based on calls by senior water rights holders, including potentially a call made on behalf of the water rights for the Project. In the event of call by the Project or other senior water rights holders, USFWS may not be able to exercise this transferred water right due to regulation by OWRD. For purposes of this PA, the KBPM assumes that diversions at the Ady Canal associated with this transferred water right will be approximately 11,000 AF.

Water diversions by the USFWS to the Ady Canal pursuant to the water right transferred from the Agency Lake and Barnes Ranch properties are not subject to UKL control logic, given that in approving this transfer, OWRD determined that this water would have historically been diverted and consumed upstream of UKL.

In addition to water from the Project, water associated with the transferred water right from the Agency Lake and Barnes Ranch properties, local tributary runoff (e.g., Sheepy Creek), and groundwater sources utilized by the USFWS (all when available), LKNWR receives water from the Tule Lake Sumps via the Tule Lake Tunnel and Pumping Plant D, which are all Project facilities.

TID operates and maintains the Tule Lake Sumps, Pumping Plant D, and the Tule Lake Tunnel. Generally, Pumping Plant D is operated as necessary to maintain water surface elevations in the Tule Lake Sumps consistent with rules and regulations issued by Reclamation (primarily for flood control purposes), levels to meet USFWS migratory bird/wildlife needs, and ESA requirements.

Deliveries to LKNWR via Pumping Plant D have significantly decreased in recent years due to drought, regulatory limitations on Project diversions, and increases in power costs associated with pumping. The historical average annual volume pumped dating back to 1941 is approximately 70,000 AF. Over the last 10 years the annual average volume has been under 20,000 AF. Regardless, these pumping activities are not part of Reclamation's PA and are not modeled in the KBPM, which focuses on UKL and the Klamath River.

4.3.3 Operation and Delivery of Water to the East Side of the 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.

Clear Lake and Gerber reservoirs are used to store seasonal runoff to meet irrigation needs of the Project and to prevent flooding in and around Tule Lake. Stored water from Clear Lake and Gerber reservoirs is generally used for irrigation purposes within Langell Valley Irrigation District (LVID), Horsefly Irrigation District (HID), and for lands covered by individual contracts; however, Reclamation can and historically has at times released water from both reservoirs for use for irrigation purposes within KID and TID (see USBR 2018a pp. 5–6 regarding Relcamation's water supply contracts with KID and TID).

Stored water released from Clear Lake Reservoir is generally diverted at Malone Diversion Dam into either the West Canal or East Malone Lateral. The East Malone Lateral serves approximately 1,800 acres on the east side of the Lost River. The West Canal serves approximately 6,750 acres within LVID. The West Canal also has a spill structure at its terminus, so that water can be discharged into the Lost River for re-diversion and use within HID. Stored water from Clear Lake Reservoir can also be released through the spillway gates on Malone Diversion Dam, for use within LVID, HID, KID, and TID.

Stored water released from Gerber Reservoir is generally diverted at Miller Creek Diversion Dam into the North Canal, for irrigation use within LVID. The North Canal serves approximately 9,550 acres within LVID.

In addition to irrigation deliveries, Reclamation makes flood control releases from Clear Lake and Gerber reservoirs, when conditions necessitate.

The POR for hydrologic data for this proposed action as it relates to the east side of the Project is water years 1903 through 2016 for Clear Lake Reservoir, and water years 1925 through 2016 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 5-year period covered by the proposed action. The POR for irrigation operations with reliable data is considerably shorter for each body of water, encompassing water years 1986 through 2016 for both Clear Lake Reservoir and Gerber Reservoir

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

4.3.3.1 *Clear Lake Operations*

Under the PA, Clear Lake Reservoir will provide a range of water supplies consistent with historical operations necessary to meet demand throughout the period covered by this BA. Reclamation proposes to operate Clear Lake Reservoir to meet the full irrigation demand of the Project, while maintaining the end of September minimum elevation. Historical annual releases vary based on available water supply and demand, with an average release of approximately 35,000 AF, based on the POR for which adequate data is available (1986-2016). With 35,000 AF being the approximate average annual release from Clear Lake Reservoir, a volume greater than 35,000 AF will be released in approximately half of years. Historical releases from Clear Lake Reservoir have ranged from zero AF, when no irrigation water supply was available, to more than 115,000 AF when flood control operations occurred. Water supply for irrigation purposes is generally used from April 15 – September 30 of each year. The outlet at Clear Lake Dam is generally opened on April 15 and closed by October 1, although slight deviations have occurred in the 1986-2016 POR. The typical release rate during irrigation season is approximately 120 cfs, with a typical maximum irrigation release of approximately 170 cfs. Releases can be greater during flood control operations and when irrigation demand is high. Table 4-3 summarizes monthly releases from Clear Lake Reservoir by month for the April through October time period. Some releases have also historically occurred during the months of February and March, primarily for flood control, and are not included in the Table 4-4.

Table 4-4. Summary of monthly 1986-2016 Clear Lake Reservoir releases.

	April	May	June	July	August	September	October
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	0.22	5.22	6.10	7.68	7.34	5.56	0.00
Average	2.58	5.45	6.41	6.99	6.54	4.71	0.04
Maximum	31.27	29.20	16.32	15.73	18.68	27.44	0.42

Available water supply from Clear Lake Reservoir is estimated annually using a seasonal forecasting model (USBR 2018a Appendix 4 Section D). The model allows Reclamation to estimate available water supplies and provide insight on appropriate deliveries that will provide elevations greater than the end of September minimum reservoir elevation, while taking into account projected inflows, typical delivery patterns, seepage, and evaporation. Changes in releases during the irrigation season are largely dictated by irrigation demand throughout the spring/summer period. Table 4-5 lists the end of September minimum proposed elevation for Clear Lake Reservoir.

Table 4-5. Minimum Clear Lake Reservoir end of September elevation (USBR Datum).

Water Body	Elevation (feet)
Clear Lake Reservoir	4,520.6

4.3.3.2 *Gerber Reservoir Operations*

Under the PA, Gerber Reservoir will provide a range of water supplies consistent with historical operations that are necessary to meet demand throughout the period covered by this BA. Reclamation proposes to operate Gerber Reservoir to meet the full irrigation demand of the Project, while maintaining the end of September minimum elevation. Historical annual releases vary based on available water supply and demand, with an average of approximately 35,000 AF, based on the POR for which adequate data is available (1986 through 2016). With 35,000 AF being the approximate average annual release from Gerber Reservoir, a volume greater than 35,000 AF will be released in approximately half of years. Historical releases from Gerber Reservoir have ranged from approximately 1,000 AF, when little irrigation water supply was available, to almost 95,000 AF when flood control operations occurred. Water supply for irrigation purposes is generally used from April 15 to September 30 each year. The outlet of Gerber Dam is generally opened on April 15 and closed on

October 1, although slight deviations have occurred in the 1986 through 2016 POR. The typical release rate during irrigation season is approximately 120 cfs with a typical maximum irrigation release of approximately 170 cfs. Releases can be greater during flood control operations and when irrigation demand is high. Table 4-6 summarizes monthly releases from Gerber Reservoir by month for the April through October time period. Some releases have also historically occurred during the months of November through March, primarily for flood control, and are not included in the table below.

Table 4-6. Summary of monthly 1986 through 2016 Gerber Reservoir releases (thousand acre-feet).

	April	May	June	July	August	September	October
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	0.10	5.56	6.76	7.87	7.53	6.08	0.00
Average	1.46	4.88	6.44	7.22	6.58	5.39	0.07
Maximum	17.03	7.85	8.63	8.94	8.35	7.34	0.80

Historically, approximately 2 cfs is bypassed and released into Miller Creek during the winter months to prevent a valve in the dam from freezing and to improve conditions for ESA-listed suckers that may be present in pools below the dam when irrigation deliveries are not occurring. This bypass has typically occurred in late October or early November until the beginning of the following irrigation season, although it has occurred as early as July. Reclamation intends to continue the 2 cfs bypass from Gerber Reservoir as part of operations in this PA. In the event of a mid-irrigation season shut off (as occurred in 2015), or concerns about meeting minimum lake elevations, Reclamation will coordinate with the USFWS on whether opening the frost valves is warranted.

Available water supply from Gerber Reservoir is estimated annually with a seasonal forecasting model. The model allows Reclamation to estimate available water supplies and provide appropriate deliveries that will provide elevations greater than the established end of September minimum lake elevation while taking into account projected inflows, typical delivery patterns, seepage, and evaporation. Changes in releases during the irrigation season are largely dictated by irrigation demand throughout the spring/summer period. Table 4-7 lists the end of September minimum proposed elevation for Gerber Reservoir.

Table 4-7. Minimum Gerber Reservoir end of September elevation (USBR Datum).

Water Body	Elevation (feet)
Gerber Reservoir	4,798.1

4.3.3.3 *Coordination with PacifiCorp*

PacifiCorp is required by its HCP with the Services (PacifiCorp 2013) to implement flow-related operations consistent with Reclamation's BiOp requirements. This, combined with the fact that Reclamation's PA includes IGD as a compliance point, means close coordination between

Reclamation and PacifiCorp is necessary for implementation of the PA and corresponding BiOps.

All IGD target flows will be determined and coordinated with PacifiCorp three days in advance. Reclamation will also provide an IGD target forecast for an additional 11 days using projections based on NRCS UKL inflow forecasts (if available), California Nevada River Forecast Center hydrologic forecasts (namely, for accretions and some UKL tributaries), meteorological forecasts, measured flows, historical patterns, and professional judgement. If these information sources do not adequately predict flows for ongoing operations, Reclamation may ask PacifiCorp to provide accretion estimates between Keno and Iron Gate as they have since the 2013 BiOp. This additional 11 days of forecasted IGD flow targets is intended to provide additional advanced planning opportunities for resource managers and PacifiCorp. However, provisional flow targets provided for these additional 11 days are estimates and the actual IGD target flows will be determined after the upper Klamath Basin hydrologic conditions and LRD to IGD accretions are actually observed.

PacifiCorp has successfully coordinated with Reclamation to implement the requirements associated with the 2013 BiOp for the last 5 years and Reclamation expects this close coordination to continue for the implementation of Project operations resulting from this consultation. In addition, emergencies may arise that necessitate PacifiCorp to deviate from the IGD release target. These emergencies may include, but are not limited to, flood control, and facility and regional electrical service emergencies. Reclamation will closely coordinate with PacifiCorp should the need to deviate from the IGD flow target be identified due to an emergency. Such emergencies occur infrequently and are not expected to significantly influence flows downstream of IGD.

On a weekly basis, Reclamation will assess how the actual observed IGD flows compare to the target flows and communicate any necessary adjustments of LRD releases to PacifiCorp. During periods of rapid hydrologic change and/or during an urgent in-season flow schedule adjustment, it may be necessary to coordinate with PacifiCorp more frequently. PacifiCorp will make every attempt to follow the flow schedule provided by Reclamation (and based on the EWA distribution/IGD formulaic approach) as closely as possible within the operational constraints of the Klamath Hydroelectric Project facilities and based upon their obligations under the existing HCP (PacifiCorp 2013), except when requested otherwise by Reclamation for events such as flushing flows and enhanced May/June flows. If Reclamation determines that actual mean daily flows deviate from the flow schedule above the percentages described above, Reclamation may need to coordinate with PacifiCorp, the Services, the FASTA Team, and Klamath Basin Area Office (KBAO) Area Manager to take corrective action, which may result in the need for a formal in-season deviation from the formulaic approach for IGD targets and EWA distribution. The relative effect of deviating from the flow schedule depends on many hydrologic, climatologic, and ecologic factors, and the same amount of deviation from the flow schedule does not warrant the same response in all situations. For example, a deviation of 100 cfs downstream of IGD when flows are in excess of 3,000 cfs may not require the same consideration as a deviation of 100 cfs when IGD flows are at 900 cfs. Each instance will need to be considered on a case-by-case basis. NMFS will have discretion over whether the deviations from the flow schedule is consistent with the PA and ultimately determine if the effects are within the bounds of their analysis.

Reclamation will provide PacifiCorp with adequate lead time when implementing deviations from the formulaic approach. Reclamation will make every attempt to provide 2 weeks advanced notice to PacifiCorp when requesting flow schedule adjustments. In some circumstances, Reclamation may request PacifiCorp to respond in less than 2 weeks if the adjustment to the flow schedule is urgent due to the need to respond to real-time and/or emergency conditions that warrant rapid response (i.e., fish disease, fish die-off, poor water quality, unexpected hydrologic conditions, imminent flooding or other health and safety issues, etc.). Finally, this section is not inclusive of all possible Reclamation-PacifiCorp coordination needs and processes. Additional coordination details regarding specific management actions (i.e., ramping rates) are contained in other sections of the BA.

4.3.3.4 *Water Rights Regulation in the Upper Klamath Basin*

The KBPM does not separately account for additional inflows to UKL that occur due to enforcement of water rights by OWRD in the Upper Klamath Basin. Part 1.3.2 of Reclamation's BA for further information regarding the ACFFOD, the doctrine of prior appropriation as applied in the State of Oregon, and water rights enforcement by OWRD (USBR 2018a pp. 23–25). The KBPM treats all inflow the same for purposes of the PA, regardless of whether that inflow has been altered by upstream tributary water diversions (or the lack thereof).

Consistent with the laws of the State of Oregon, live flow that is physically available at the established point or points of diversion for a water right is subject to appropriation for beneficial use, subject to any restrictions that may exist on the exercise of that water right as a matter of state and/or Federal law. Accordingly, additional inflow to UKL resulting from water rights regulation in the Upper Klamath Basin is available for appropriation and beneficial use within the Project, just like any other live flow that may exist in UKL. However, as noted above, state and Federal law, including the ESA, may nevertheless limit the extent to which this water can be appropriated and applied to beneficial use. Accordingly, additional inflow to UKL due to water rights regulation in the Upper Klamath Basin is subject to the same operational regime as outlined in this PA, with respect to ESA requirements, as all other water in UKL.

There is one notable exception to this aspect of the PA, necessitated by Oregon law. As discussed in Section 1.3.2., Project water rights recognized in the ACFFOD are currently enforceable, absent a judicial stay. In accordance with the doctrine of prior appropriation, when the amount of live flow available for appropriation in UKL and the Klamath River is insufficient to meet the actual beneficial irrigation demands within the Project, a call may be made on the Project water rights determined in the ACFFOD. However, OWRD's administrative rules provide that an otherwise enforceable call may be disregarded if the water made available due to enforcement is not available for use or is not otherwise being used by the senior rights holder making the call. See Or. Admin. R. §690-250-020. Accordingly, as part of this PA, to the extent a call is made on Project water rights, the additional inflow to UKL resulting from the call will be delivered for irrigation purposes within the Project in addition to the Project Supply.

In the event of a Project call, for purposes of this PA and overall compliance with the ESA, Reclamation proposes the following process to quantify and deliver for irrigation purposes available UKL inflow resulting from a Project call:

- Reclamation will quantify inflow to UKL as a result of a Project call. Reclamation retains discretion regarding the quantification method.

- Reclamation will review the quantification method with the Services and UKL inflow rates and volumes resulting from a Project call.

- Reclamation will make the final determination whether, and to what extent, the additional water resulting from a Project call can be delivered from UKL for irrigation use within the Project consistent with Reclamation's obligations under the ESA.

- Reclamation will continue to monitor deliveries of Project Supply, including any deliveries as a result of a Project call for consistency with the PA and BiOp, including potentially adjusting UKL central tendency to account for these inflows.

The Oregon Water Resources Department (OWRD) is responsible for regulating water rights in the State of Oregon. Reclamation has no role in this process except to the extent of making a call on Project water rights when the amount of water physically available at the designated points of diversion for the Project is inadequate to meet beneficial irrigation demands within the Project. This process explains how and to what extent Reclamation will determine and make additional water available to the Project due to water rights regulation, consistent with ESA.

4.4 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.

4.4.1 Dams and Reservoirs

4.4.1.1 *Exercising of Dam Gates*

The gates at Gerber, Clear Lake, and Lost River Diversion Dams, and the A Canal, Ady Canal, Link River fish ladder, 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.

The frost valves at Gerber Dam are exercised annually in order to prevent freezing of dam components. Valves are opened in the fall, at the end of irrigation season, at a flow rate of approximately 2 cfs and closed in the spring once persistent freezing temperatures have ceased.

4.4.1.2 *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.

At LRD, the replacement of the remaining wood stop logs with concrete stop logs is proposed to occur over the next 3 to 5 years. This action may require in-water work; a floating caisson (i.e., a watertight chamber) will be placed in front of the stop log bay and then filled with water in order to submerge and seal the bay. Once sealed, the bay would be de-watered to allow for maintenance and stop log replacement. When work is completed, air would be pumped into the caisson so that it floats to the surface, and the caisson would be moved to another bay to begin work. Appropriate Reclamation staff would be on-site during the de-watering process to conduct fish salvage as needed.

At the LRDC, the removal and rebuild of the headgates is currently required. A stop log bay will need to be created at the channel headworks to isolate the headgates for replacement. The stop log bay will be involved installation of structural “C” channel beams in the channel walls and pier noses to allow for placement of a steel bulkhead. With a bulkhead in place, water flow can be controlled and allow for the removal of the gates. No de-watering is necessary for this activity; however, some in-water work will be 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.

4.4.1.3 *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.

4.4.1.4 *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.

4.4.1.5 *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.

4.4.1.6 *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.

4.4.1.7 *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.

4.4.1.8 *Roads and Dikes*

Road and dike maintenance, including gravel application, grading, and mowing, occurs as necessary from April through October. Pesticides and herbicides are also used on Reclamation managed lands, primarily canal rights-of-way to control noxious weeds on an annual basis from February through October (in compliance with the Pesticide Use Plan). Techniques used to control noxious weeds may include cultural, physical, and chemical methodologies for aquatic and terrestrial vegetation. The effects of these activities have been evaluated in previous section 7 consultations, and incidental take coverage was provided in the USFWS's BiOps 1-7-95-F-26 and 1-10-07-F-0056 dated February 9, 1995, and May 31, 2007, respectively. In both BiOps, the USFWS determined that pesticide application would not jeopardize the continued existence of LRS and SNS. The products are still being used to minimize take and are in compliance with current Integrated Pest Management Plans required by the Reclamation Manual's Directive and Standard ENV 01-01. At this time, there have been no changes to the action.

4.4.1.9 *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. Aquatic weeds that collect on trash racks and around pump facilities are removed on a daily basis.

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 are 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.

Should a pump require repair, the pump chamber would be isolated from the water conveyance facility by placement of a gate, bulkhead, or coffer dam. The chamber would then be de-watered to allow for maintenance access. Appropriate staff would be on-site to perform fish salvage, as necessary.

4.5 Water Shortage Planning

Reclamation generally follows an established process for identifying and responding to the situation where available water supplies are inadequate to meet beneficial irrigation demands within the Project. During the fall-winter period, Reclamation coordinates directly with KDD and the USFWS regarding Project water availability and demands (for both refuge and irrigation purposes). Reclamation does not make any public announcement of the volume of water available during the fall-winter period for delivery to the Project, including LKNWR. Near the beginning of the spring-summer irrigation season, Reclamation issues an annual Operations Plan, which identifies the anticipated volume of water available from the various sources utilized by the Project, and the associated operating criteria applicable that year. The Operations Plan is posted on Reclamation's website, a press release is issued, and copies are sent by letter to Project water users and affected Tribes.

In the event of an anticipated shortage in the volume of water available for irrigation use from Clear Lake and Gerber reservoirs, Reclamation coordinates the allocation and delivery of limited supplies with LVID, HID, and others with a contractual right to receive stored water from these reservoirs. In the event of an anticipated shortage in the volume of water available for irrigation use from UKL and the Klamath River, Reclamation will coordinate with irrigation districts and water users regarding anticipated irrigation demands within the Project.

If the volume of water or the timing when it is available is less than the anticipated demands of these two districts, Reclamation may determine it necessary to issue an Annual Drought Plan (Drought Plan), which identifies and explains how water from UKL and the Klamath River is to be allocated among various entities with different contractual priorities to Project. The Drought Plan is posted on Reclamation's website, a press release is issued, and affected Project water users are provided a copy and notified by letter of the volume of water available under their respective contract.

The Drought Plan will identify an initial allocation for entities and individuals with a secondary priority to Project water from UKL and the Klamath River. Reclamation then updates the allocation (either increasing or decreasing the water available) as the irrigation season progresses and hydrologic conditions change, again notifying affected contractors by letter. Reclamation attends district board meetings, calls contractors by telephone, and answers direct inquiries related to the Drought Plan allocation. In addition to possibly allocating the available water through the Drought Plan, there are other actions that Reclamation can take or directly facilitate, in response to a shortage in water available from the Project.

Consistent with Reclamation policy, Reclamation may administratively approve the transfer of water between districts and individual water users within the Project. Such transfers do not increase the amount of water available to the Project or expand the Project's service area but rather simply change the place of use within the Project. Prior to approval, Reclamation reviews each application on a case-by-case basis to make sure these basic conditions are met. These internal transfers are generally used by irrigators to address a shortage in the water available under a given contract, based on the contractual priority it provides to Project water. Overall, these types of transfers promote the efficient and economical use of water. Internal Project transfers are also available for irrigable lands within Lower Klamath and Tule Lake NWRs, subject to the approval of the USFWS. Water made available to a NWR through an internal transfer approved by Reclamation is separate from any water that may be available for delivery to the NWR consistent with the terms of this PA.

As has occurred in the past, Reclamation may also engage in irrigation demand reduction activities within the Project, on a year-by-year basis. There is no program currently in place for such activities, but such efforts have occurred periodically over the last two decades, subject to proper legal authority and the availability of Federal appropriations. In the past, these activities have included agreements with individual landowners to forgo use of Project water or to produce supplemental groundwater.

4.6 Conservation Measures

The t bGHyterm "conservation measure" is defined as an action to benefit or promote the recovery of listed species that are included by the Federal agency as an integral part of the PA. These actions will be taken by the Federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or action which the Federal agency or applicant have committed to complete in a BA or similar document. The conservation measures proposed assist Reclamation in best meeting the requirements under section 7 of ESA by (1) "…utilizing our authorities in furtherance of the purpose of this Act by carrying out programs for the conservation of endangered species…" and (2) avoiding actions that jeopardize the continued existence of listed species.

4.6.1 Canal Salvage

Fish salvage of Project canals occurs when canals are: (1) temporarily dewatered for a discrete action related to maintenance and/or repairs at Project facilities (described in Section 4.3), and (2) when canal systems are dewatered at the end of each irrigation season. Under both circumstances fish are salvaged from pools where they are stranded. Reclamation proposes, in coordination with USFWS, to continue the salvage of suckers both for routine maintenance and repair at Project structures and at conclusion of the irrigation season when Project canals, laterals, and drains are dewatered consistent with past salvage efforts since 2005.

At conclusion of each irrigation season, Reclamation will coordinate fish salvage activities with irrigation districts, principally KID and TID. Future fish salvage of the canal system will include areas where suckers are annually encountered in reliable numbers since 2005, including the A Canal forebay, C4 Canal, D1 Canal, and D3 Canal within the KID and J Canal within the TID. Other locations within the Project canals will be periodically checked during dewatering and fish will be salvaged if deemed feasible and productive. Reclamation will also continue to pursue alternative methods of dewatering canals, laterals, and drains and which could result in less sucker presence within these facilities at the end of the irrigation season. Fish salvage will be coordinated with USFWS each year.

Reclamation will coordinate with USFWS on the disposition of endangered suckers resulting from salvage activities, including release to natural waters or retention for disease treatments, studies, and captive rearing.

4.6.2 Sucker Assisted Rearing Program

Since 2000, Reclamation has supported various conservation measures within the upper Klamath Basin which have resulted in significant improvements to the Baseline (including fish screen installation at A Canal and Geary Canal, removal of Chiloquin Dam on the lower Sprague River, fish passage at LRD, increasing wetland and lake habitat at the Williamson River Delta, and annual salvage of suckers from canals). However, there are few, if any, practicable options for reducing incidental take which is an effect of the Project.

Reclamation proposes to continue support of a captive rearing effort by USFWS for LRS and SNS. The intention is to improve the numbers of suckers reaching maturity in UKL. Ultimately, the function of a captive rearing program would be to promote survival and recovery of the sucker populations that suffer losses from entrainment as a result of the Project or other threats. Captive propagation is already an important part of listed fish recovery efforts nation- wide, including at least three sucker species (i.e., June sucker, razorback sucker, and robust redhorse sucker).

The USFWS has already implemented initial efforts to rear LRS and SNS to a size that may increase individual survival. Sucker larvae collected from Williamson River were reared in tanks and holding ponds for approximately 2 years. Juvenile suckers salvaged from Project canals have also been held prior to release to UKL. Based on these efforts, captive rearing of LRS and SNS appears feasible and practicable. Reclamation envisions that future efforts by USFWS will expand on these initial efforts.

Specifically, Reclamation proposes support of a captive rearing program by providing funding in the amount of $300,000 annually. These funds will be used to cover costs associated with capture, rearing, release, and monitoring of released suckers in UKL. As requested by USFWS, Reclamation staff will provide personnel assistance with the rearing program when not in conflict with other necessary work. The USFWS will have oversight of the rearing program. Reclamation's support of the captive propagation program would be for the period of this consultation (April 1, 2019 to March 31, 2024) and adhere to regulations of an interagency agreement between USFWS and Reclamation. The program is envisioned as having a positive effect on the species that offsets impacts due to entrainment at LRD, A Canal, and other Project facilities. Monitoring will determine the actual effectiveness and the program's continuation will be coordinated between Reclamation and USFWS.

4.6.3 Sucker Monitoring and Recovery Program Participation

Since about 2000, Reclamation has funded monitoring of sucker populations in the lakes and reservoirs of the Upper Klamath Basin. Reclamation has also funded projects identified through USFWS' Sucker Recovery Implementation Team since 2013 and participated in the Recovery Implementation Team discussions and project identification. In coordination with USFWS, Reclamation proposes to continue efforts to monitor adult suckers in UKL, Clear Lake and Gerber Reservoirs, monitor juvenile suckers in UKL and Clear Lake, and fund sucker research, restoration and recovery actions throughout the Upper Klamath Basin. Contingent upon Reclamation's annual budget process and appropriations, Reclamation anticipates annual funds of approximately $1.5 million base funding annually with an additional $700,000 for the first 2 years (fiscal year 2019 and 2020) for UKL adult monitoring, Clear Lake adult monitoring, and juvenile cohort monitoring, research, and recovery projects. Funding in fiscal years beyond 2020 will be supplemented with $700,000 should appropriations materialize. Reclamation envisions that monitoring and research projects funded through the Recovery Program will answer questions about sucker recruitment in UKL and sucker population trends in both UKL and Clear Lake Reservoir. Reclamation also envisions that projects under a sucker Recovery Program will improve the amount and quality of sucker habitats, sucker passage issues, and sucker survival in the Upper Basin thereby offsetting PA impacts to habitat and entrainment of suckers at UKL, Gerber Reservoir, and Clear Lake Reservoir.

In coordination with USFWS, Reclamation proposes to continue participation in the Klamath Sucker Recovery Program. The 2013 Revised Recovery Plan for the LRS and the SNS (Plan) outlines a strategy for a Recovery Program (USFWS 2013a). Reclamation has worked with USFWS toward achieving the goals and objectives of the Plan since 2013 and intends to continue to do so, including dedication of resources determined in coordination between Reclamation and the USFWS and participation on recovery efforts.

4.6.4 Coho Restoration Grant Program

Reclamation will provide $700,000 annually in 2019 and 2020, and $500,000 from 2021 through 2023 for program administration and projects that address limiting factors for SONCC coho salmon in the Klamath Basin and contingent upon Reclamation's annual budget process and appropriations. Funding in fiscal years beyond 2020 will be supplemented should appropriations materialize. The program targets projects that have both the greatest impact on promoting survival and recovery and provide sustainable and lasting ecological benefits in the Klamath River Basin for coho salmon. Projects given the highest priority under this program include access improvement and barrier removal, improved habitat and access to coldwater refugia, instream habitat enhancement and protections, and water conservation. Restoration projects minimize habitat related effects of the Project by individually and comprehensively improving critical habitat conditions for coho individuals, populations, and overall.

As described in Reclamation's BA, Reclamation includes conservation measures proposed to benefit or promote the recovery of ESA-listed suckers. This listed species is under the jurisdiction of USFWS. NMFS analyzed the conservation measures Reclamation proposed for ESA-listed suckers. NMFS determined that the proposed conservation measures for suckers do not have any effects to ESA-listed species or designated critical habitat under the jurisdiction of NMFS because the actions will all occur above Iron Gate Dam where there are no such listed species or designated critical habitat. Thus, NMFS has not included these measures in this Opinion's project description or effects analysis.

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 USFWS has determined there are no interdependent or interrelated actions associated with Reclamation's proposed action considered in this BiOp.

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

In this section, we assess the range-wide condition of the LRS and the SNS. We describe factors, such as life history, distribution, population size and trends, which help determine the likelihood of both survival and recovery of the species. We also present the environmental baseline of the species, to which the effects of the proposed action will be compared.

The distribution of LRS and SNS is largely contained within the action area for the current proposed action (Figure 3-1). The only locations that LRS and SNS are known to occur that do not fall within the action area are the tributaries UKL, Clear Lake, and Gerber Reservoir that contain spawning habitat. A small number of LRS and SNS may remain in these tributaries outside the spawning season due to stranding or volitionally; however, the vast majority of individuals that use these tributaries migrate into them during the spring spawning season and reside within the action area for most of the year. Thus, the status of the species within the action area is essentially equivalent to the range-wide status of the species.

The USFWS recently completed a Species Status Assessment (SSA) meant to serve as the basis for defining the status and environmental baseline for consultation under section 7 of the ESA (USFWS 2019). As such, this section will provide an overview of the ecology of the species, its status, and the threats; both similar and complementary information related the status of the species can be found in the SSA (USFWS 2019).

6.1 Legal status

The LRS and the SNS were federally listed as endangered throughout their entire ranges on July 18, 1988 (USFWS 1988). They are also listed as endangered by the States of California and Oregon (California Department of Fish and Game 2004). In 2012, the status of each of these species was reviewed by the USFWS (USFWS 2013b, 2013c). The USFWS has initiated a new 5-year status review of the LRS and the SNS (USFWS 2018 p. 28252), and this review will be completed in 2019. A final revised recovery plan for these species was published in 2013 (USFWS 2013a).

6.2 Life History

LRS and SNS are large-bodied, long-lived fishes. The oldest individual for which age has been estimated was 57 years for LRS and 33 years for SNS (Buettner and Scoppettone 1991 p. 21, Terwilliger et al. 2010 p. 244). Juveniles grow rapidly until reaching sexual maturity sometime between four and nine years of age for LRS and between four and six years of age for SNS (Perkins et al. 2000b pp. 21–22). On average, approximately 90 percent of adults of both species survive from year to year, though survival may vary among populations, which enables populations to persist through periods with unfavorable spawning or recruitment conditions (Hewitt et al. 2018 pp. 17, 21). Upon achieving sexual maturity, LRS are expected to live on average 12.5 years based on annual survival rates (Hoenig 1983, USFWS 2013a p. 12). Similarly, SNS adults are estimated to live on average 7.4 years after having joined the adult population. Females produce a large number of eggs per year: 44,000 to 236,000 for LRS and 18,000 to 72,000 for SNS, of which only a small percentage survive to become juveniles as is typical for freshwater fish (Houde 1989 p. 479, Houde and Bartsch 2009 p. 31).

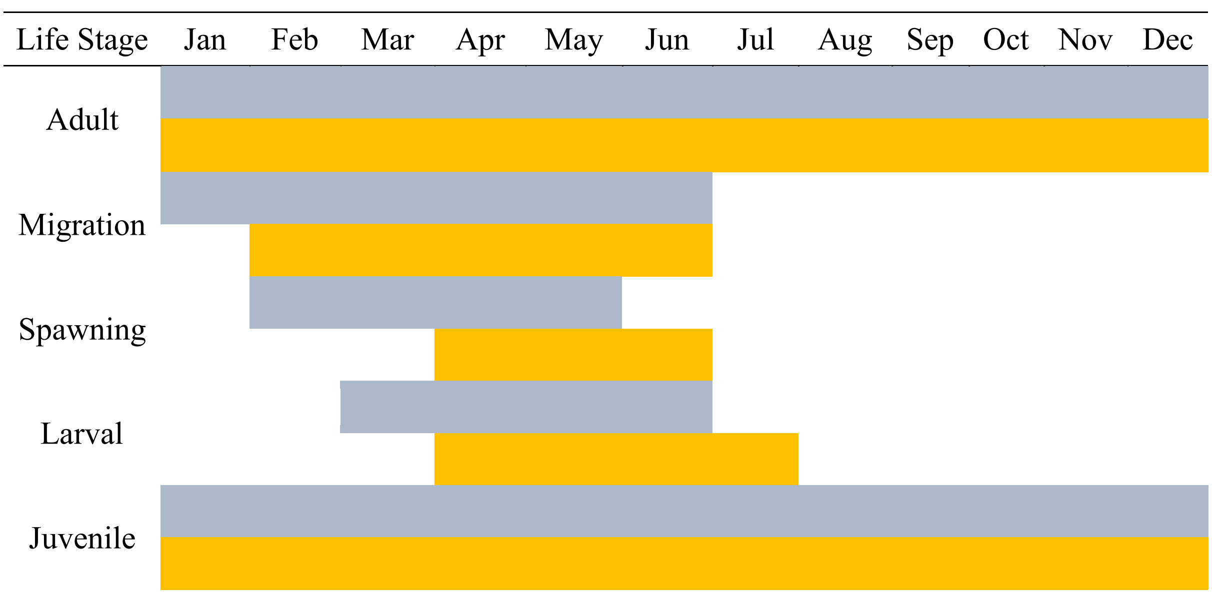


Figure 6-1. Life Stage Diagram (adapted from Reiser et al. 2001 pp. 4–3). LRS are represented by blue and SNS are represented by yellow.

LRS and SNS can generally be classified into five life stages and behaviors that occur at various times throughout the year: migration, spawning, larval, juvenile, and adult (Figure 6-1). The timing of occurrence of each life stage is similar between the two species, with the main difference occurring during spawning and incubation.

6.2.1 Migration

To complete their life cycle LRS and SNS require distinct growth and spawning habitats. Growth occurs in the lakes of the Upper Klamath Basin, and spawning habitat is typically found in the tributary rivers to these lakes. However, a subset of LRS use lakeshore groundwater upwelling areas (springs) as their spawning habitat in UKL. Small numbers of SNS are also detected at these lakeshore sites (Hewitt et al. 2017 p. 24), but the low numbers suggest that they are likely just vagrant individuals not attempting to spawn. Because most individuals utilize distinct growth and spawning habitats, they must complete a spawning migration to reproduce.

Adult LRS and SNS in UKL appear to strongly cue on water temperature to initiate spawning migrations up the Williamson River, which is the only tributary to UKL with large spawning populations of LRS and SNS. Migrations begin only after appropriate water temperatures have been achieved: 10°C (50°F) for LRS and 12°C (54°F) for SNS (Hewitt et al. 2017 pp. 11 & 24), and decreasing temperatures can reduce numbers of individuals migrating upstream (Hewitt et al. 2014 pp. 36–37). Migration into Willow Creek, which is believed to contain the only spawning habitat available from Clear Lake, appears to be triggered by a general rise in stream temperatures rather than exceedance of a specific temperature threshold (Hewitt and Hayes 2013).

Successful migration to spawning habitats can be limited by hydrologic conditions. In UKL, access to the Williamson River does not appear to be affected by river flows or lake elevations, but access to and/or suitability of the lakeshore springs habitat can be reduced by shallow depths or dewatering at springs due to low lake elevations (Burdick et al. 2015b, entire). Access to spawning habitat into Willow Creek, which is the only spawning habitat available from Clear Lake, can be limited by shallow water near the mouth or low flows within the stream (Hewitt and Hayes 2013 p. 7). The specific effects of hydrologic conditions on access to spawning habitats are discussed below in Section 6.5.2.

6.2.2 Spawning

Spawning occurs from February through May (Figure 6-1). In the Lost River drainage, the bulk of upstream migration occurs in March and April (Hewitt and Hayes 2013 pp. 13, 15). In UKL, some spawning occurs in March, but the bulk occurs in April and early May (Hewitt et al. 2014 p. 9). As suckers spawn, fertilized eggs quickly settle within the top few inches of the gravel substrate until hatching, around one week later.

Generally, individuals of both species spawn every year in UKL, although data from the 2018 spawning season suggested that some individuals may have skipped spawning. In Clear Lake and Gerber Reservoir, suckers skip spawning in some years due to limited access. Spawning activity is typically observed over mixed gravel or cobble substrates in depths typically less than 0.46 m (1.5 ft) ranging from 0.12 to 0.70 m (0.4 to 2.3 ft) in rivers and shoreline springs. Gravel is rock ranging in size from 2 – 64 mm (0.8 – 2.5 in) in diameter, and cobble ranges in size from 65 – 256 mm (2.5 – 10 in) in diameter.

Eggs require flowing water and relatively open substrate that permits sufficient aeration (both from ambient dissolved oxygen [DO] levels and from removal of silt and clays that can smother the egg). These conditions are also important for the elimination of waste materials from the egg during incubation. LRS were observed to spawn at water velocities of 15 – 82 cm/sec (0.49 - 2.69 ft/sec; (Coleman et al. 1988 p. iv). Eggs also require appropriate temperatures to support timely development. Coleman et al. (1988 p. iv) observed that LRS eggs hatched 8 days after fertilization at 13.5°C (56.3°F). Colder temperatures (7°C [45°F]) were observed to delay egg development by at least 2 weeks (J.E. Rasmussen, USFWS, unpublished data). Eggs also need some protection against potential predators and disease, such as small spaces in gravel, although there are no data to clarify what conditions are optimal. The small spaces between gravel pieces in the substrate help to restrict access from potential predators, and also limit the number of eggs that can randomly clump together, which could reduce the spread of diseases such as certain fungi that can grow on developing eggs.

6.2.3 Larvae

Larvae emerge from the gravel approximately 10 days after hatching at about 7 to 10 mm (0.2 to 0.6 in) total length and are still mostly transparent with a small yolk sac (Coleman et al. 1988 p. 27). Generally, LRS and SNS larvae spend little time in rivers after swim-up, drifting downstream to the lakes at about 14 mm (0.55 in) in length around 20 days after hatching (Cooperman and Markle 2003 pp. 1146–1147). In the Williamson and Sprague Rivers (UKL population) and Willow Creek (Clear Lake Reservoir population), larval drift downstream from the spawning grounds begins in April and is typically completed by July with the peak in mid-May (Scoppettone et al. 1995 p. 19). Most downstream movement occurs at night near the water surface (Ellsworth et al. 2010 pp. 51–53). Little is known about the drift dynamics of the larvae hatched at the eastern shoreline springs in UKL.

Once in the lake, larvae tend to inhabit near-shore areas (Cooperman and Markle 2004, entire, Erdman et al. 2011 pp. 476–477). Larval density is generally higher within and adjacent to emergent vegetation than in areas devoid of vegetation (Cooperman and Markle 2004 p. 370). Emergent vegetation provides cover from non-native predators (such as non-indigenous fathead minnows; *Pimephales promelas*) and habitat for prey items (Cooperman and Markle 2004 p. 375, Crandall 2004 p. 3). Such areas may also provide refuge from wind-blown currents and turbulence, as well as areas of warmer water temperature which may promote accelerated growth (Crandall 2004 p. 5, Cooperman et al. 2010 p. 36). These areas of emergent vegetation tend to occur along the fringes of the lakes in shallower areas. However, the two species appear to have slightly different habitat usage as larvae; SNS larvae predominantly use nearshore areas adjacent to and within emergent vegetation, but LRS larvae tend to occur more often in open water habitat than near vegetated areas (Burdick and Brown 2010 p. 19).

6.2.4 Juveniles

Larvae transform into juveniles in mid-July at 20 and 30 mm (0.8-1.2 in) total length and transition from predominantly feeding at the surface to feeding near the lake bottom (Markle and Clauson 2006 p. 496). In UKL, some juvenile suckers continue to use relatively shallow (less than approximately 1.2 m [3.9 ft]) vegetated areas, but overall juveniles are found in a wide variety of habitats including deeper, un-vegetated off-shore habitat (Buettner and Scoppettone 1990 pp. 32, 33, 51, Hendrixson et al. 2007 pp. 15–16, Burdick et al. 2008 pp. 427–428, Bottcher and Burdick 2010 pp. 12–14, Burdick and Brown 2010 pp. 42, 45, 50). One-year-old juveniles occupy shallow habitats during April and May, but have been found in higher concentrations in deeper areas along the western shore of UKL as the summer progresses until DO levels become reduced (Bottcher and Burdick 2010 p. 17, Burdick and Vanderkooi 2010 pp. 10, 11, 13). Once DO levels in this deeper area become suboptimal, juveniles appear to move into shallower areas throughout the rest of the lake.

6.2.5 Adults

Adult LRS and SNS use the lakes of the Upper Klamath Basin as their primary habitat for feeding and growing; they migrate to spawning habitats during spring as described in Sections 6.2.1 and 6.2.2. In their growth habitat, adult suckers require adequate food, water quality, and refuge from predation. Both spawning subpopulations of LRS in UKL have experienced an average annual survival rate of around 91 percent between 2002 and 2015 (range: 80-96 percent across locations and sexes; Hewitt et al. 2018 pp. 12 & 17). SNS experienced average annual survival rates of 84 percent between 2001 to 2015 (range: 74-95 percent; Hewitt et al. 2018 p. 21). Although adult sucker are hardier than juveniles and larvae, they are still susceptible to poor water quality, which can be associated with die-offs (see Section 6.5.4). Thus, adult suckers require adequate water quality, or at least refugia from poor water quality conditions, within their growth habitat.

Adult LRS and SNS are distributed throughout the northern portion of UKL during summer (Banish et al. 2009 p. 160), but in the spring, congregations form in the north-east quadrant of the lake prior to moving into tributaries or shoreline areas for spawning. There is no information on their distribution in the lake during fall and winter. Less is known about populations in Gerber and Clear Lake Reservoirs because they have been studied much less (Leeseberg et al. 2007, entire). However, in Clear Lake adults appear to inhabit the western lobe of the reservoir more so than the eastern lobe (Barry et al. 2009 p. 3), which is probably due to its greater depth.

Based on radio-telemetry studies of suckers in UKL, adults of both species tend to avoid depths of less than 2 m (6.6 ft) and most individuals are found at depths of 2-4 m (6.6-13.1 ft; Banish et al. 2007 p. 10, 2009 pp. 159–161). An exception to these patterns occurs during poor water quality conditions when suckers tend to seek refuge from stressful conditions in the shallow habitats in and around spring-fed areas such as Pelican Bay (Banish et al. 2009 pp. 159–160). These spring-dominated sites likely provide better water quality conditions because the water is typically cooler (cooler water can hold more oxygen than warmer water) and clearer because of the flowing nature of area. Selection of deeper than average habitats may reflect the distribution of their prey or it may confer protection from avian predators, which can consume suckers as large as 730 mm (28.7 in; Evans et al. 2016 p. 1262).

The limited available data on adult LRS and SNS diets, which come from Clear Lake, suggest that LRS tend to feed directly from the lake bottom whereas SNS primarily consume zooplankton from the water column (Scoppettone et al. 1995 p. 15). This diet difference aligns with the mouth morphology of the species; SNS have terminal or subterminal (forward-facing) mouths whereas LRS have more ventral (bottom-facing) mouths (Miller and Smith 1981 pp. 1 & 7).

6.3 Range and Distribution

6.3.1 Historical Distribution

LRS and SNS are endemic to the upper Klamath Basin, including the Lost River sub-basin (Figure 1). Documented historical occurrences of one or both species include UKL (Cope 1879 pp. 784–785) and Tule Lake (Bendire 1889 p. 444, Eigenmann 1891 p. 667), but the species likely occupied all of the major lakes within the upper Klamath Basin, including Lower Klamath Lake, Lake Ewauna, and Clear Lake. In addition to inhabiting the lakes throughout the upper basin, the species historically utilized all major tributaries to the lakes for spawning and rearing. For example, the species ascended the Williamson River in the thousands and were "taken and dried in great numbers by the Klamath and Modoc Indians" (Cope 1879 p. 785). Historically, large sucker spawning migrations also occurred from Tule Lake up the Lost River to near Olene and Big Springs near Bonanza (Bendire 1889, entire). Suckers were also known to spawn in great numbers at several springs and seeps along the eastern shoreline of UKL, including Barkley (Bendire 1889 p. 444) and likely spawned at other spring-dominated areas in the northwestern corner of the lake, including Harriman, Crystal, and Malone Springs.

At the time of listing (1988), LRS and SNS were known to occupy UKL and its tributaries and outlet (Klamath Co., Oregon), including a "substantial population" of SNS in Copco Reservoir (Siskiyou Co., California), as well as collections of both species from Iron Gate Reservoir (Siskiyou Co., California) and J.C. Boyle Reservoir (Klamath Co., Oregon) (Figure 6-2). Remnants and/or highly hybridized populations were also documented to occur in the Lost River system (Klamath Co., Oregon, and Modoc and Siskiyou Co., California) including both species in Clear Lake Reservoir (Modoc Co., California), but it was apparently presumed that LRS populations in Sheepy Lake, Lower Klamath Lake, and Tule Lake (Siskiyou Co. California) had been "lost" (USFWS 1988 p. 27130). Although not stated explicitly, SNS within Gerber Reservoir (Klamath Co., Oregon) were likely part of the "highly hybridized populations" in the Lost River Basin referenced in the listing.

6.3.2 Current Distribution

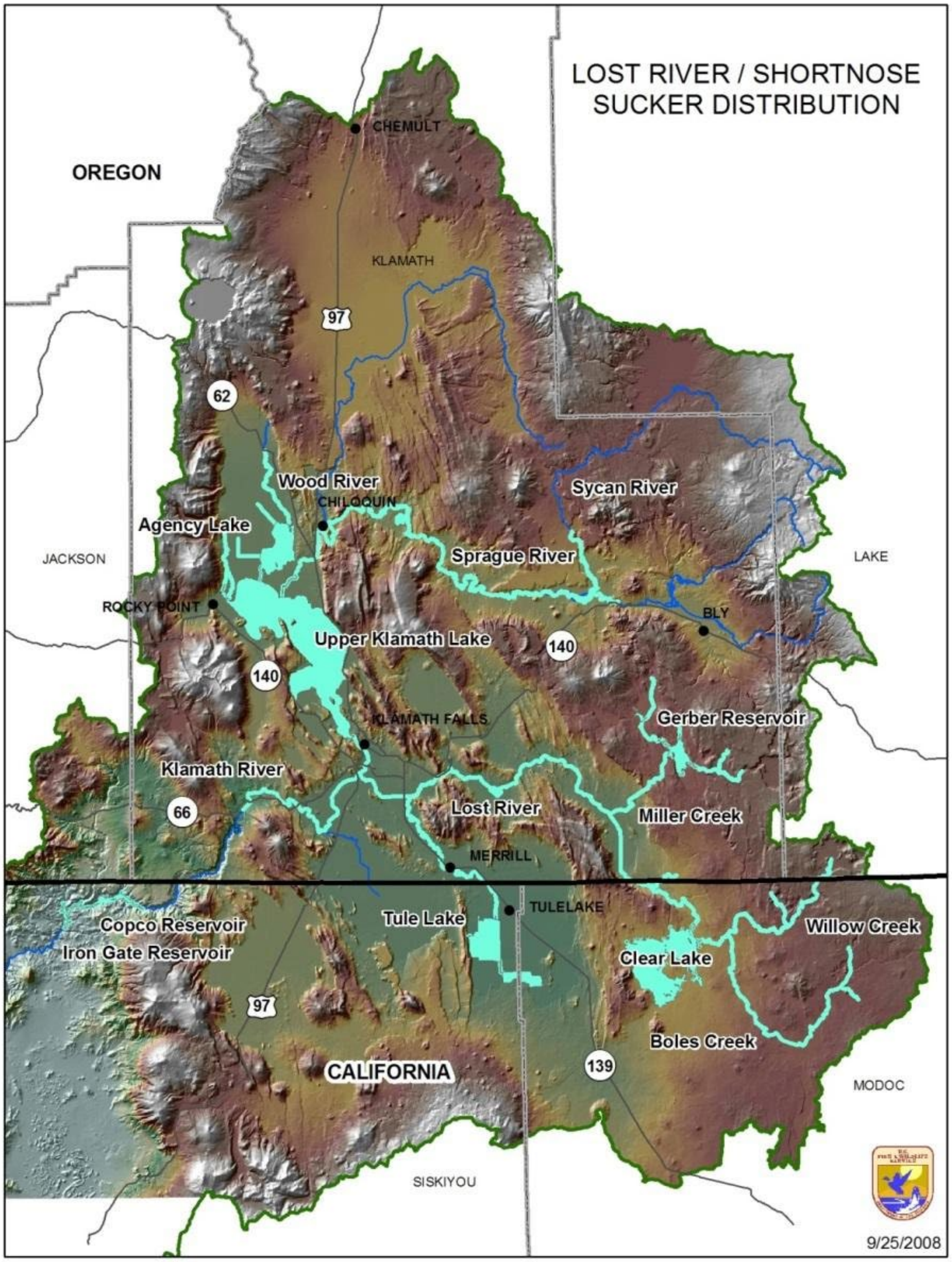


Figure 6-2. The Lost River and SNS are endemic to the lakes and rivers of the Upper Klamath Basin in south, central Oregon and north, central California. Lower Klamath Lake and Sheepy Lake are not depicted on the map because populations no longer occur there.

6.3.2.1 *UKL*

At approximately 64,000 acres (26,000 hectares), UKL is the largest remaining contiguous habitat for endangered suckers in the Upper Klamath Basin. UKL is a natural lake that was dammed in 1921 to allow for management of lake elevations both higher and lower to support irrigation deliveries. Approximately 70 percent of the original 50,400 acres (20,400 hectares) of wetlands surrounding the lake, including the Wood River Valley, was diked, drained, or significantly altered between 1889 and 1971 (Gearhart et al. 1995 p. 7). Spawning aggregations at numerous locations within the UKL system have disappeared, but LRS continue to use two spawning locations in relatively large numbers: the Williamson River and the eastern shoreline springs, and UKL contains the largest remaining population of LRS by far. SNS are only known to spawn in significant numbers in the Williamson River.

Spawning in the Williamson River and the Sprague River, its major tributary, occurs primarily in a 7.8 km (4.8 mile) stretch continuing from the Williamson River downstream of the confluence with the Sprague to the historical Chiloquin dam site on the Sprague River. Although the Chiloquin dam was removed in 2008, only small numbers of suckers migrate beyond the historical dam site to spawn (Martin et al. 2013 p. 10).

6.3.2.2 *Clear Lake*

The present-day Clear Lake Reservoir ranges from 8,400 to 26,000 acres (3,400 to 10,400 hectares), depending on lake elevation. Clear Lake is a natural lake that was greatly increased in size after damming in 1910. It is a shallow, turbid lake with little wetland vegetation. The primary inflow to Clear Lake comes from Willow Creek, which is characterized by relatively flashy hydrology. Willow Creek and its major tributary, Boles Creek, contain the only known spawning habitat available to SNS and LRS in Clear Lake. There is approximately 43 km (27 miles) of stream spawning and migratory habitat utilized by LRS and 105 km (65 miles) utilized by SNS in this watershed. Due to the flashy hydrology, access to the spawning habitat can be reduced in years without significant snowpack to support sustained spring run-off.

6.3.2.3 *Gerber Reservoir*

Gerber Reservoir is only inhabited by SNS and the non-listed KLS. The dam built on Miller Creek in 1925 created Gerber Reservoir with a maximum surface area of 3,830 acres (USBR 2000a p. 12). There are two spawning tributaries, Barnes Valley Creek and Ben Hall Creek, which combined have roughly 32 km (20 miles) of potential habitat (spawning or migratory). This population of SNS has similar population dynamics to Clear Lake Reservoir populations, but data are much sparser.

6.3.2.4 *Other Lakes and Reservoirs*

Other endangered sucker populations also contain small numbers in a handful of other waterbodies. These populations are comprised predominantly of SNS, but a smaller number of LRS are also present. Both SNS and LRS are found in Lake Ewauna (Kyger and Wilkens 2011a

p. 3), Tule Lake (Hodge and Buettner 2009 p. 4), hydropower reservoirs along the Klamath River (Desjardins and Markle 2000 pp. 14–15), and the Lost River proper (Shively et al. 2000 pp. 82–86).

6.3.3 Population Abundance and Dynamics

Starting in the late 1800s, 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 1900s, 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 2001 p. 98), 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. 2000a, entire). Over that 3-year period, more than 7,000 dead suckers were collected, and many other suckers likely died but were not detected.

The wide-ranging behavior, expansive habitat, and rarity of these species make obtaining accurate population estimates challenging. However, long-term monitoring using capture-recapture methods provide accurate information on relative changes in abundance (Hewitt et al. 2018, entire), and abundance can be roughly estimated for some populations based on the size of catches and the proportion of individuals that are tagged in annual sampling.

6.3.3.1 *UKL*

UKL likely contains the largest remaining populations of both LRS and SNS, though the SNS population in Clear Lake may be similar in size. Although robust abundance estimates are difficult for this population due to low recapture rates of tagged fish, these recapture rates can be used to obtain rough estimates of abundance. Over the last decade, abundance estimates were roughly 100,000 adult LRS river-spawners, 8,000 adult LRS shoreline-spring-spawners, and 19,000 adult SNS (Hewitt et al. 2014 p. 16). However, in 2018, the estimates of fish participating in spawning aggregations were estimated to be much lower: 32,000, 8,000, and 7,000, respectively (D. Hewitt, USGS, personal communication August 16, 2018). These estimates may not reflect the true population size due to the statistical challenges of estimating abundance from the available data, particularly if some individuals skipped spawning in 2018. Overall, the populations in UKL are characterized by high annual survival of adults (Hewitt et al. 2018 pp. 12, 17, 21). These adults spawn successfully and produce larvae, but few juveniles survive their first year, and captures of individuals 2-6 years old is exceedingly rare (Burdick and Martin 2017 p. 30). Similarly, there has not been evidence of significant numbers of new individuals joining the adult spawning populations since the late 1990s (Hewitt et al. 2018 p. 24), and the lack of significant recruitment has led to sharp declines in population sizes (Hewitt et al. 2018 pp. 14, 20, 24).

Survival of adult SNS and LRS in UKL varied little over the past decade. Annual adult survival rates of the SNS in UKL appear to vary more than the LRS, but adult survival for both species in UKL appears to have been relatively stable since high quality estimates became available in the early 2000s (Hewitt et al. 2018 pp. 12, 17, 21). Adult LRS in UKL average approximately 93% survival annually (Hewitt et al. 2017 pp. 15, 21). The approximate average adult SNS annual survival in UKL is slightly less at 87% (Hewitt et al. 2017 p. 28). However, preliminary data indicate that survival from spring 2016 to spring 2017 (i.e., 2016 survival) was low for both species, in some cases lower than has been observed during the period with robust estimates. For SNS, preliminary estimates for 2016 survival are 77% for females and 74% for males. The preliminary estimates of survival for both sexes are 78% for LRS spawning in the Williamson River and 85% for LRS spawning at the lakeshore springs (D.A. Hewitt, USGS, personal communication, August 16, 2018). Additionally, hundreds of dead adult suckers were observed during a die-off in the summer of 2017, and data to resolve whether the die-off event influenced annual survival rates will not be available until later in 2019 because survival estimates are confounded with detection probabilities in the final interval for the survival model.

Juvenile mortality and the resulting lack of recruitment of new individuals into the adult populations have led to steep declines in LRS and SNS populations in UKL. Although there is uncertainty about the rates of decline, the best available estimates indicate that the LRS lakeshore springs spawning population declined by approximately 56 percent for females and 64 percent for males between 2002 and 2015 (Hewitt et al. 2018 p. 10, Figure 6-3). The decline in the Williamson River LRS population is more difficult to assess due to sampling issues specific to that population (Hewitt et al. 2018 pp. 25–26), but it is likely that the population dynamics are similar to those of the shoreline springs population. The SNS population in UKL has also declined substantially since 2001, losing approximately 77 percent of females and 78 percent of males between 2001 and 2016 (Hewitt et al. 2018 p. 19, Figure 6-3).

Recent LRS and SNS size distribution trends reveal that the adult spawning populations within UKL are composed of similar-sized, similar-age relatively old individuals. Median lengths of individuals of both species in UKL generally increased since the between the 1990s and 2010, but since about 2010 size distributions have been more or less stable among years (Hewitt et al. 2018 pp. 19, 22–23, 27, 29). This indicates that few new individuals are joining the adult populations. The fish recruited in the 1990s are now approximately 28 years old and are well beyond the average survival past maturity of 12 years for the SNS and equal to that of 20 years for the LRS.

The effects of senescence on the survival and reproduction of these two species are unknown at present, but the populations in UKL are clearly aging (Hewitt et al. 2018 pp. 15, 18, 21). The low recent survival rates could be an early signal that senescence is leading to increased mortality rates and accelerated population declines. Additional years of survival data will help to resolve whether the low survival reveals increased mortality of aging individuals or unique environmental conditions to that year.

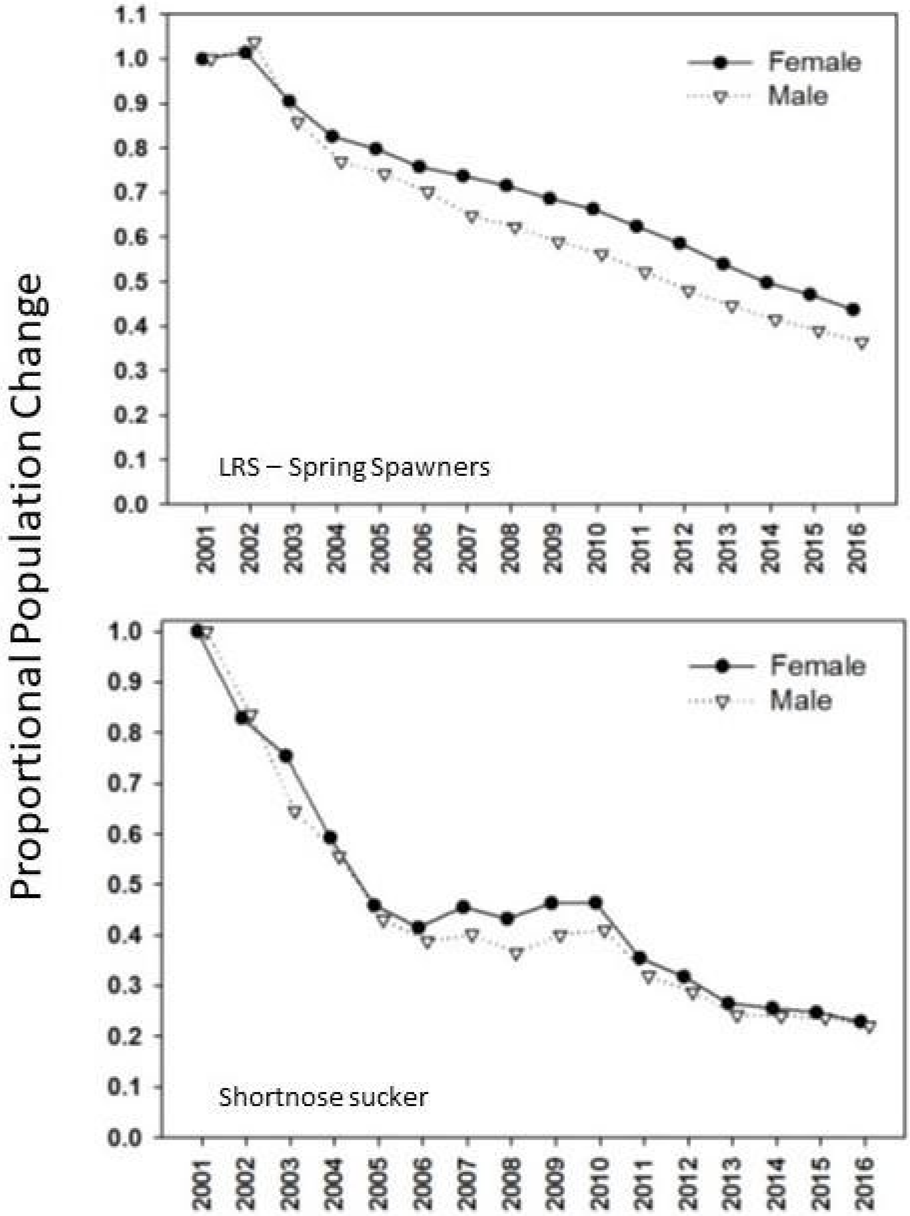


Figure 6-3. Adult spawning populations of suckers in UKL have consistently declined since at least 2001, as estimated by two approaches using mark-recapture models in Program MARK (from Hewitt et al. 2018 pp. 14 & 20). The number of spawning female LRS in UKL has declined by nearly 60 and SNS by 80 percent between 2002 and 2016.

Both species spawn successfully in the Sprague River, producing larvae that drift downstream to UKL. Captures of 1,000s to 10,000s of larvae from the Sprague and Williamson Rivers (Cooperman and Markle 2003 pp. 1146–1147, Ellsworth and Martin 2012 p. 32) conservatively suggest that combined larval production of both species is on the order of 1,000,000s; note that these numbers are rough estimates and not a characterization of inter-annual variation, which is also substantial. Successful spawning in the Sprague River suggests that the needs of both species for spawning access and suitable egg incubation habitat are at least minimally met; however, available information does not permit comparisons with historical conditions.

LRS also spawn successfully at groundwater seeps along the UKL margin. No robust estimates of larval production at these sites exist but given the number of LRS females and average fecundity, it is likely that millions of larvae hatch annually, even with the expected high mortality of eggs. There is typically access to these areas between February and May; however, lake elevations lower than approximately 4,141.4-4,142.0 ft (1,262.3-1,262.5 m) reduce the number of spawning individuals and the amount of time spent on the spawning grounds. UKL elevations less than 4,142.0 ft (1,262.5 m) occurred by May 31 in 6 years between 1975 and 2017, which is equivalent to 14 percent of spawning seasons. Thus, lake elevations have the potential to negatively impact spawning for LRS, but this has rarely occurred over the last 43 years.

Although numerous larvae are produced annually, the number of juveniles captured during sampling efforts is low and typically decreases to nearly zero in late summer. Very few individuals are captured as age-1 or older (Burdick and Martin 2017 p. 30), suggesting complete cohort failure each year. The declines in captures commonly occur during the periods with the most degraded water quality conditions in UKL, but a clear empirical link between water quality parameters and mortality rates has not been established. One prominent hypothesis is that water quality is directly responsible for the unnaturally high levels of juvenile mortality. Another is that water quality interacts with other sources of mortality by causing chronic stress that renders the individuals more susceptible to forms of predation or infection (USFWS 2019 pp. 21–41). The specific causes of repeated cohort failure at the juvenile stage are a critical uncertainty challenging recovery because juvenile mortality is the primary factor that contributes to the low resilience of both LRS and SNS populations in UKL.

Even though viable eggs and larvae are produced each year, there is a lack of recruitment of new adults into UKL sucker populations, which continue to exist only because of their long life. 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. Both species are expected to become extirpated from UKL without significant recruitment, but the current dynamics are particularly untenable for the SNS, and without substantial recruitment in the next decade, the population will be so small that it is unlikely to persist without intervention (Rasmussen and Childress 2018 p. 586).

6.3.3.2 *Clear Lake*

Data for the Clear Lake populations are very limited compared to those in UKL, but we can make some generalizations. Clear Lake currently supports the largest populations of both suckers in the Lost River drainage. SNS and LRS survival rates appear to be slightly less than conspecifics in UKL and more variable with some annual estimates as low as 47 percent (D.A. Hewitt, Personal Communication, September 14, 2017), but the estimates are somewhat uncertain given the low detection probabilities. Size distributions of LRS in Clear Lake have few year classes represented, whereas the SNS population exhibits relatively broad representation across adult sizes (Hewitt and Hayes 2013 pp. 14, 16). However, the SNS population in Clear Lake Reservoir is highly introgressed with KLS (Tranah and May 2006 p. 313, Dowling et al. 2016 pp. 10–11), as described below in Sections 6.4.1.1 and 6.5.5.

Despite our inability to accurately estimate absolute abundance of the populations due to the lack of robust data, the low numbers of captures and recaptures suggests that these populations are smaller than those in UKL. This is particularly true for LRS.

In Clear Lake, SNS are more abundant than LRS. Approximately 5,100 tagged SNS were detected during the spawning run during 2016; slightly more than 800 tagged LRS were detected during the same period (D.A. Hewitt, Personal Communication, September 14, 2017). Although reliable estimates of total population numbers are unavailable, the data suggest it is unlikely that more than 25,000 adult SNS and 10,000 adult LRS occur in Clear Lake. Between 2004 and 2010, only 1,360 individual LRS were captured in Clear Lake Reservoir for all years combined (Hewitt and Hayes 2013 p. 5). In comparison, captures in UKL of LRS averaged over 2,000 individuals annually with more than 12,000 individuals captured during this same time period (Hewitt et al. 2017 p. 12). Clear Lake is sampled in the fall whereas UKL is sampled in spring while the fish are congregated in preparation for spawning migrations, but the magnitude of the difference suggests that the LRS population in Clear Lake Reservoir is much smaller than the LRS population in UKL. The Clear Lake LRS population also appears to be much smaller than the Clear Lake SNS population. Over the 2004 to 2010 period, 4.5 times as many individual SNS (6,240 individuals) were captured in Clear Lake Reservoir compared to LRS (Hewitt and Hayes 2013 p. 6). The average annual captures of individual SNS in Clear Lake Reservoir (1,040 per year) is comparable to UKL rates (1,350 individuals), which may suggest that the population sizes are similar.

One important source of larval mortality in Clear Lake Reservoir is predation by several native or non-native aquatic species, including blue chub, fathead minnow, Sacramento perch, or bullfrog. Also, entrainment by flows through the Clear Lake dam into the Lost River appears to be a significant impact to suckers and juveniles. Although a fish screen was installed when Clear Lake dam was replaced in 2003, it is estimated around 270,000 larval and 3,600 juvenile suckers were entrained through the dam in 2013 (Sutphin and Tyler 2016 p. 10). Nevertheless, when spawning conditions are suitable for producing strong annual cohorts—estimated to be slightly less than half of the years (Hewitt and Hayes 2013)—juveniles, particularly SNS, can survive to recruit to the adult population. Evidence for this is seen in the multiple age classes of juveniles captured during sampling (Burdick and Rasmussen 2013 p. 14), as well as the diverse size class distributions of adults (Hewitt and Hayes 2013 p. 16). LRS adults in Clear Lake Reservoir exhibit more restricted size class distributions and less consistent recruitment (Hewitt and Hayes 2013 p. 14). For example, a cohort that appeared in the trammel net sampling in 2007 was not evident in sampling in subsequent years, but the drivers of this mortality and the more tenuous status of Clear Lake LRS are unknown.

6.3.3.3 *Gerber Reservoir*

Spawning surveys of the SNS population in Gerber Reservoir in 2006 detected approximately 1,700 of the nearly 2,400 SNS that had been tagged the previous year (Barry et al. 2007a p. 7). Based on mark-recapture data from 2004 (Leeseberg et al. 2007, entire), 2005, and 2006 (Barry et al. 2007a, entire), the population of SNS may have been as high as 42,000 individuals. In 2015, drought conditions reduced water levels within the reservoir to approximately 1 percent of the maximum storage. This undoubtedly reduced SNS numbers because of the limited available habitat, but we do not have specific data to accurately estimate the extent of this reduction, although Reclamation initiated population monitoring work in 2018. Similarly, due to a lack of robust data, we are not able to estimate survival rates.

The outlet of Gerber Reservoir does not have a fish screen, so suckers are vulnerable to entrainment downstream into Miller Creek, which historically connected to the Lost River, but is now completely blocked and diverted for irrigation purposes. Small numbers of juvenile suckers (10s to 100s per year) have been caught in Miller Creek (Shively et al. 2000 p. 89, Hamilton et al. 2003 pp. 3–4), but the proportion of juveniles entrained and the population impacts of entrainment are largely unknown.

6.3.3.4 *Other Lakes and Reservoirs*

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.

Data on LRS and SNS populations in Keno Reservoir, Klamath River reservoirs, Tule Lake, Gerber Reservoir, and the Lost River are limited. Limited monitoring of 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, entire), Keno Reservoir (Kyger and Wilkens 2011a, entire), and the Klamath River reservoirs below Keno (Desjardins and Markle 2000, entire). SNS dominate in the Keno Reservoir and downstream in the hydropower reservoirs (Desjardins and Markle 2000 p. 39, Kyger and Wilkens 2011a p. 7).

Lake Ewauna probably functions as a subpopulation to UKL to some degree. Hundreds of listed suckers (both species) have been captured, tagged, and translocated to UKL from Lake Ewauna since 2010 (Kyger and Wilkens 2011a p. 3, USBR 2018b). There is a fish ladder at Link River Dam that provides some connectivity between Lake Ewauna and UKL, though only small numbers of individuals have been documented using it. Although water quality conditions are consistently quite poor during late summer and early fall, small numbers of endangered suckers apparent persist in Lake Ewauna, perhaps by using the Link River as a refuge from poor water quality conditions (Piaskowski 2003 p. 9). Successful spawning in the Link River, which is the only potential spawning habitat below Link River Dam, has not been documented, though there is an anecdotal report of spawning behaviors in the river (Smith and Tinniswood 2007 p. 1).

Tule Lake was extensively diked, and its volume has been greatly reduced through evaporation related to retention of water above dams and irrigation as well as diversion of water to the Klamath River as well as to Lower Klamath National Wildlife Refuge through the D Pump. The remaining lake habitat, referred to as Sump 1A and Sump 1B, is approximately 9,081 acres and 3,259 acres, respectively. Hundreds of individuals of both species were captured in Tule Lake Sump 1A during a 3-year effort (Hodge and Buettner 2009 pp. 4–6). Spawning aggregations have been observed in the Lost River below Anderson Rose dam, but the habitat is not high quality. Locations in the Lost River where historical spawning was documented, such as Olene, are inaccessible from Tule Lake due to multiple dams and inundation behind dams. Thus, the Tule Lake populations are considered sinks, entirely composed of the offspring of other populations that found their way through the Lost River or the irrigation system into Tule Lake and without sufficient means to be self-sustaining.

In the main stem hydropower reservoirs on the Klamath River, a two year effort produced slightly more than 200 captures, 99 percent of which were SNS (Desjardins and Markle 2000 pp. 14–15). The sizes of catches given the effort suggests that these populations contain very few individuals. This population is also very likely a sink, with new individuals generally being spawned elsewhere in the system, such as UKL. None of these sink populations are thought to contribute significantly to maintaining and recovering LRS and SNS because they have extremely low resiliency due to a combination of degraded habitat, low numbers, and restricted access to suitable spawning habitat (Desjardins and Markle 2000 pp. 14–15, Hodge and Buettner 2009 pp. 4–6, Kyger and Wilkens 2011a p. 3).

6.4 Reasons for listing and new threats

The LRS and SNS were listed because of declines in the number of populations and individuals, lack of recruitment, and loss of habitat (USFWS 1988 pp. 27130–27132). Of the populations of the LRS and the SNS that remain, most are restricted in distribution and some lack the ability to successfully reproduce.

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 (USFWS 1988 p. 27131). Despite the removal of the dam in 2008, very few suckers have migrated to upstream spawning habitat (Martin et al. 2013 pp. 26–27). 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 (National Research Council 2004 pp. 53–56).

Overharvesting of adult LRS and SNS potentially contributed to declining population levels in UKL, especially for the LRS, but harvest has not been authorized since 1987 (USFWS 1988 p. 27132). 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, 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. This threat continues to persist across the range of the species to varying degrees, and little is known about the effects of specific nonnative species.

Lastly, natural die-off events resulting from blue green algae (*Aphanizomenon flos-aquae*; AFA) blooms and subsequent degradation of water quality contribute to population declines (USFWS 1988 p. 27132). As AFA increasingly dominates the system, the frequency of extreme fish die-off events has also increased in UKL (National Research Council 2004 pp. 237–240). Although water quality conditions are most severe in UKL and Keno Reservoir, listed suckers throughout the Klamath Basin are vulnerable to water quality-related mortality (USFWS 2007a pp. 17–19, 2007b pp. 16–18).

6.4.1 New Threats Identified Since Listing

6.4.1.1 *Hybridization and Introgression*

Hybridization is a single interbreeding event between individuals of two species. Introgression is the subsequent incorporation of genetic materials into the genome of the species resulting from numerous hybridization events (i.e., back crossing). Introgression is common among suckers in general and well documented among the Klamath catostomids, particularly between SNS and Klamath largescale sucker (KLS; *Catostomus snyderi*) and especially in the Lost River drainage (Dowling et al. 2016 p. 3). Ongoing introgressive hybridization is generally viewed as a negative because it potentially reduces diversity as the genes of the less numerically dominant species are replaced by the alternate species. Additionally, this process may also reduce fitness if individuals are less adapted phenotypically to exploit specific niches within an environment. Depending on the degree of this reduction, it could result in lower survival rates and reduced population resiliency. It is also possible that introgression increases diversity by introducing new and beneficial mutations into species genomes. This would possibly increase diversity both within and among populations (Dowling et al. 2016 p. 2), but for rare species it is more likely that introgression will result in a reduction of the integrity of the genome as genes from more common species overwhelm the rare species (Rhymer and Simberloff 1996 p. 83).

6.4.1.2 *Climate Change*

Climate variability, such as fluctuations between wet and dry periods, is part of natural processes; however, climatic models suggest that much of the recent trends in climate are driven by anthropogenic causes (Barnett et al. 2008 p. 1082). Annual average temperatures in the Upper Klamath Basin are expected to rise 2.1 to 3.6 °F from the 1960-1990 baseline by the decade of 2035-2045 due to climate change (Barr et al. 2010 p. 8, Risley et al. 2012 p. 4). At present, lethal temperatures for suckers are uncommon, but stressful temperatures for suckers occur with regularity (see Section 6.5.3.5). Climate change may increase the frequency and duration of these stressful temperature events and is likely to make high stress events more common.

Future changes in precipitation are highly uncertain. Annual precipitation may increase or decrease overall under climate change (Barr et al. 2010 p. 8, Risley et al. 2012 p. 4). However, climate models consistently predict that a larger proportion of annual precipitation and run-off will occur as rain events in the winter (Barr et al. 2010 p. 9, Risley et al. 2012 p. 8). Warmer temperatures during the winter are also projected to reduce the proportion of precipitation falling as snow. Precipitation in the form of snow acts somewhat as a buffer for the hydrologic system, providing more gradual and manageable input into the lakes than rain. It is difficult to predict the effects of precipitation changes to suckers, but they will alter the dynamics of spring flows, reducing the size of snowmelt runoff during the spawning season. This may restrict access to spawning areas in smaller watersheds, such as those entering Clear Lake and Gerber Reservoir, and reduce reproductive success.

6.4.1.3 *Predation, Parasitism, and Disease*

Although not mentioned at the time of listing as a threat, several species of birds prey on LRS and SNS, but the ultimate effect to the status of the species from these avian predators is currently unknown. See Section 6.5.9 for a detailed discussion of avian predation. Similarly, parasites were not identified as a threat at the time of listing, but new information suggests they could be a threat to the suckers. See Section 6.5.10 for a detailed discussion of parasitism of LRS and SNS.

Microcystin, an algal toxin that affects the liver, as well as other algal toxins are another possible threat that was not considered during the listing process. In UKL microcystin concentrations tend to be highest in August and September but can show substantial variation across sites and among years (Caldwell Eldridge et al. 2012 pp. 12–14, 2013 pp. 70, 75). In a 2007 survey, 49 percent of a sample of juvenile suckers (n = 47) collected at 11 shoreline sites exhibited indications of microcystin exposure (VanderKooi et al. 2010 p. 2). However, these data are preliminary, and the results are also consistent with improper handling of samples. Nevertheless, one hypothesis is that the toxin is indirectly ingested when suckers consume midge larvae (Chironomidae), which feed on the algae (Burdick and Martin 2017 p. 2). Juvenile LRS fed microcystin toxins through various means in a controlled experiment consistently failed to show acute mortality within the 96-hour observation period and exhibited relatively few histological abnormalities (Burdick and Martin 2017 p. 8). These latter results suggest that microcystin in UKL may not be a significant source of mortality to juvenile LRS.

6.4.2 Survival and Recovery Needs

The 2013 revised recovery plan for the LRS and SNS (USFWS 2013a p. 43) describes recovery objectives for the LRS and SNS:

Threat-based Objectives

i. Restore or enhance spawning and nursery habitat in Upper Klamath Lake and Clear Lake Reservoir systems.
ii. Reduce negative impacts of poor water quality

iii. Clarify and reduce the effects of non-native organisms on all life stages
iv. Reduce the loss of individuals to entrainment
v. Establish a redundancy and resiliency enhancement program

Demographic-based Objectives

i. Maintain or increase larval production
ii. Increase juvenile survival and recruitment to spawning populations
iii. Protect existing and increase the number of recurring, successful spawning populations.

6.4.2.1 *Recovery Units*

The 2013 revised recovery plan for the LRS and the SNS identifies recovery units for both of the sucker species (USFWS 2013a pp. 40–41). The UKL Recovery Unit is subdivided into four management units:

(1) UKL river-spawning individuals;
(2) UKL spring-spawning individuals (LRS only);
(3) Keno Reservoir Unit, including the area from Link River Dam to Keno Dam; and
(4) 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) 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. 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, 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 (USFWS 2013a pp. 43–47). 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.

6.5 Environmental Baseline

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 analysis provides a reference point for the Service assess the potential effects of the proposed action on listed species.

For section 7 consultations on continuing actions, such as Project operations, separating baseline effects from the anticipated effects of the proposed action can be difficult. Operations of existing structures, such as dams and associated infrastructure, are integrally related to the existence of the structures themselves; however, the structures are already present and 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. Because these dams are already present, blocked fish passage is not an effect of the action; rather it is part of the environmental baseline. The effects of operating structures to store, deliver, and drain water are effects of the proposed action.

6.5.1 Habitat

Loss and alteration of habitats (including spawning and rearing habitats) were major factors leading to the listing of both species (USFWS 1988 pp. 27131–27132) and continue to be significant challenges to recovery. Both species utilize a spectrum of aquatic habitats during some stage of the life cycle, including river or stream habitats, open-water lake habitats, and the wetlands areas along banks and shores. However, alterations or total loss of habitats have occurred throughout the species' range. The most dramatic examples of wholesale habitat loss include Tule Lake (roughly 36,000 hectares [89,000 acres] lost) and Lower Klamath Lake (roughly 40,700 hectares [100,500 acres] lost) (National Research Council 2004 p. 53). These two lakes were both terminal bodies with a single major tributary, which were dammed in 1910 or diked in 1917 (respectively) to completely block inflows (National Research Council 2004 pp. 55–56). This resulted in a loss of approximately 392 km^2 (151 mi^2) or 88 percent of Tule Lake and 362 km^2 (140 mi^2) or 95 percent of Lower Klamath Lake (National Research Council 2004 p. 96). As the lake levels receded, the exposed lake bottoms were converted to agricultural uses. Prior to damming, Tule Lake hosted what was probably the largest population of LRS (Bendire 1889 p. 444). Anecdotal reports suggest that populations of LRS also occurred in Lower Klamath Lake (Cope 1879 p. 72), although we are not aware of any pre-1917 reports on scientific fish surveys of the Lower Klamath Lake. Notable habitat loss also occurred in UKL. Approximately 70 percent of the original 20,400 hectares (50,400 acres) of wetlands surrounding the lake, including the Wood River Valley (Figure 6-4), was diked, drained, or significantly altered between 1889 and 1971 (Gearhart et al. 1995 p. 7). Conversely, additional habitat that is suitable for suckers was created when reservoirs were created behind Gerber Dam and enlarged behind Clear Lake Dam.

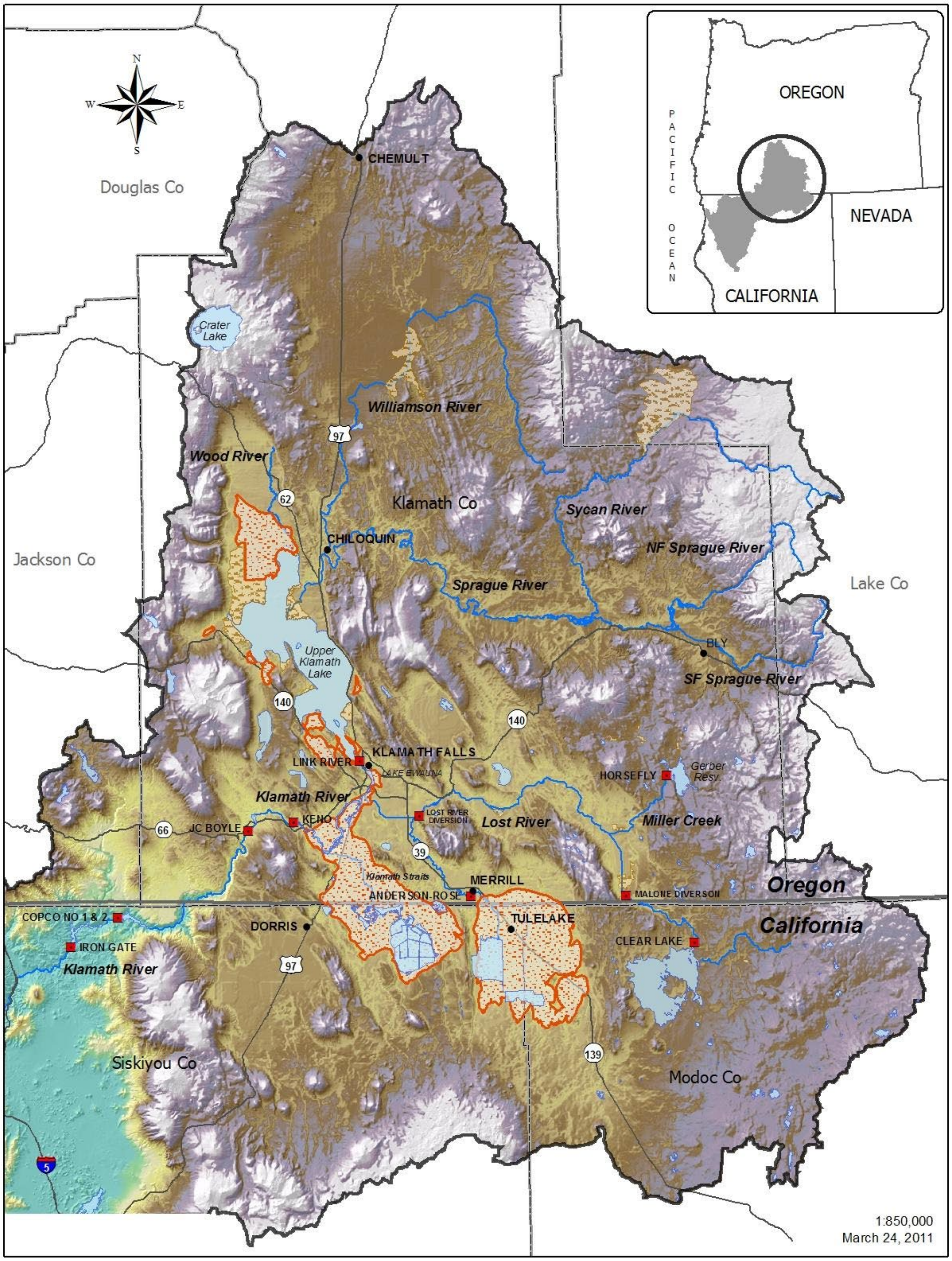


Figure 6-4. The upper Klamath Basin indicating areas of lost aquatic and wetland habitat that have been lost since 1900 with current conditions overlain. The lost areas are outlined in orange.

Barriers that limit or prevent access to spawning habitat were also identified as threats when the species were listed. Chiloquin Dam was cited as the most influential barrier because it restricted access to potentially 95 percent of historic river spawning habitat in the Sprague River for the populations in UKL (USFWS 1988 p. 27131). However, this dam was removed in 2008, improving access to approximately 120 km (75 mi) of river for spawning. Both species have been detected upstream of the dam site during the spawning season, albeit in very small numbers (Martin et al. 2013 p. 8). Additionally, several dams or water control structures hinder or completely impede movements of the species throughout their historic range. These include Gerber Dam, Clear Lake Dam, Anderson Rose Dam, Harpold Dam, Lost River Diversion Dam, Malone Dam, as well as numerous smaller check dams and the like (USBR 2000b, entire). All of the more substantial dams (i.e., the named ones above) were installed approximately 100 years ago, and none of them, except Link River Dam, have structures that would permit volitional fish passage. For example, suckers attempting to run up the Lost River from Tule Lake Sump 1A are only able to travel 12 km (7.5 mi) before the Anderson-Rose Dam blocks migration. The connection between UKL and downstream environments was questionable for many decades because of a dilapidated fish passage ladder on the Link River Dam. This condition improved with the completion of a sucker-friendly fish ladder in 2005.

Another equally important type of barrier is limited hydrologic connection to spawning or rearing habitat. This can be due to natural climatic patterns or result from human actions, such as water management for agricultural irrigation. For example, low lake levels in Clear Lake Reservoir can limit adult sucker access to Willow Creek (Hewitt and Hayes 2013, entire), the only known spawning tributary (Buettner and Scoppettone 1991 p. 8). When conditions permit access, adults ascend Willow Creek, the single major tributary flowing into Clear Lake Reservoir, spawn successfully, and produce juvenile cohorts in Clear Lake Reservoir (Buettner and Scoppettone 1991 pp. 47–48, Sutphin and Tyler 2016 p. 10). The amount of suitable shoreline spawning habitat in UKL is also affected by changes in lake elevation (Burdick et al. 2015b p. 483). Several spring-spawning populations, including Tecumseh Springs, Big Springs, and Barkley Springs, have been extirpated, in part due to reduced connectivity.

Historically, wetlands comprised hundreds of thousands of hectares throughout the range of the species (Akins 1970 pp. 42–50, Bottorff 1989 p. ii, Gearhart et al. 1995 p. 16), some of which likely functioned as crucial habitat for larvae and juveniles. Other wetlands may have played vital roles in the quality and quantity of water. Loss of ecosystem functions such as these, due to alteration or separation of the habitat, is as detrimental as physical loss of the habitat. For example, increases in sediment input to the lake and occurrence of *Aphanizomenon flos-aquae* (AFA) coincide with loss of riparian and wetland areas associated with agricultural development above UKL (Bradbury et al. 2004 p. 164). Higher inundation of fringe wetland habitats have been associated with higher larval survival in UKL (Cooperman et al. 2010 p. 34). Of the approximately 102 km^2 (39.3 mi^2) of wetlands still connected to UKL, relatively little functions as rearing habitat for larvae and juveniles, partly due to lack of connectivity with current spawning areas and habitat alterations.

6.5.2 Water Quantity

The volume of water available in the action area at any one time depends 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, relative humidity, and other factors. Water quantity can affect the amount of available LRS and SNS habitat and the connectivity among habitats used in different seasons. In UKL, 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 592,932 acre-feet (1992) to a high of 1,977,714 acre-feet (1983). The average and median annual net inflows during the period of record are 1,202,011 and 1,051,059 acre-feet, respectively. Approximately 48 percent of the annual inflow occurs between October and February, 44 percent between March and June, and 8 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 (USBR 2018a Appendix 4 p. 4–23). 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 et al. 2011 p. 11). Therefore, evaluation of trends in net inflow is enhanced by understanding trends in flow in the Williamson River. Additionally, because the Williamson is largely disconnected from the primary snowmelt-runoff production of the Cascade mountain range, Williamson River flows are a reasonable indicator of hydrology in the Upper Klamath Basin.

Evaluation of baseline hydrology involved the analyses of flow data for the Williamson River (used as a proxy for total UKL inflow) and surface elevation data for Clear Lake and Gerber Reservoir. Though the proposed action was based upon a period of record spanning water years 1981 to 2016, consideration of baseline hydrology extends to the broadest period of reliable data available for these sites. Williamson River flow data extend from water years 1918 through 2017; Clear Lake data encompass water years 1905 through 2018; and Gerber Reservoir data run from water year 1926 through water year 2018.

Williamson River flow data were taken from USGS gage 11502500 Williamson River below Sprague near Chiloquin, OR at a daily time step. All data are labeled as approved for publication by USGS. Daily flow data in cubic feet per second (cfs) were converted to a daily volume in thousands of acre-feet (TAF). Daily volumes were summed for each water year to give a total annual volume of water passing by the USGS gage site and plotted by water year (Figure 6-5). As these annual data are highly variable, a locally estimated scatterplot smoothing (LOESS) technique was applied to the data to illustrate trends across the observed period of record.

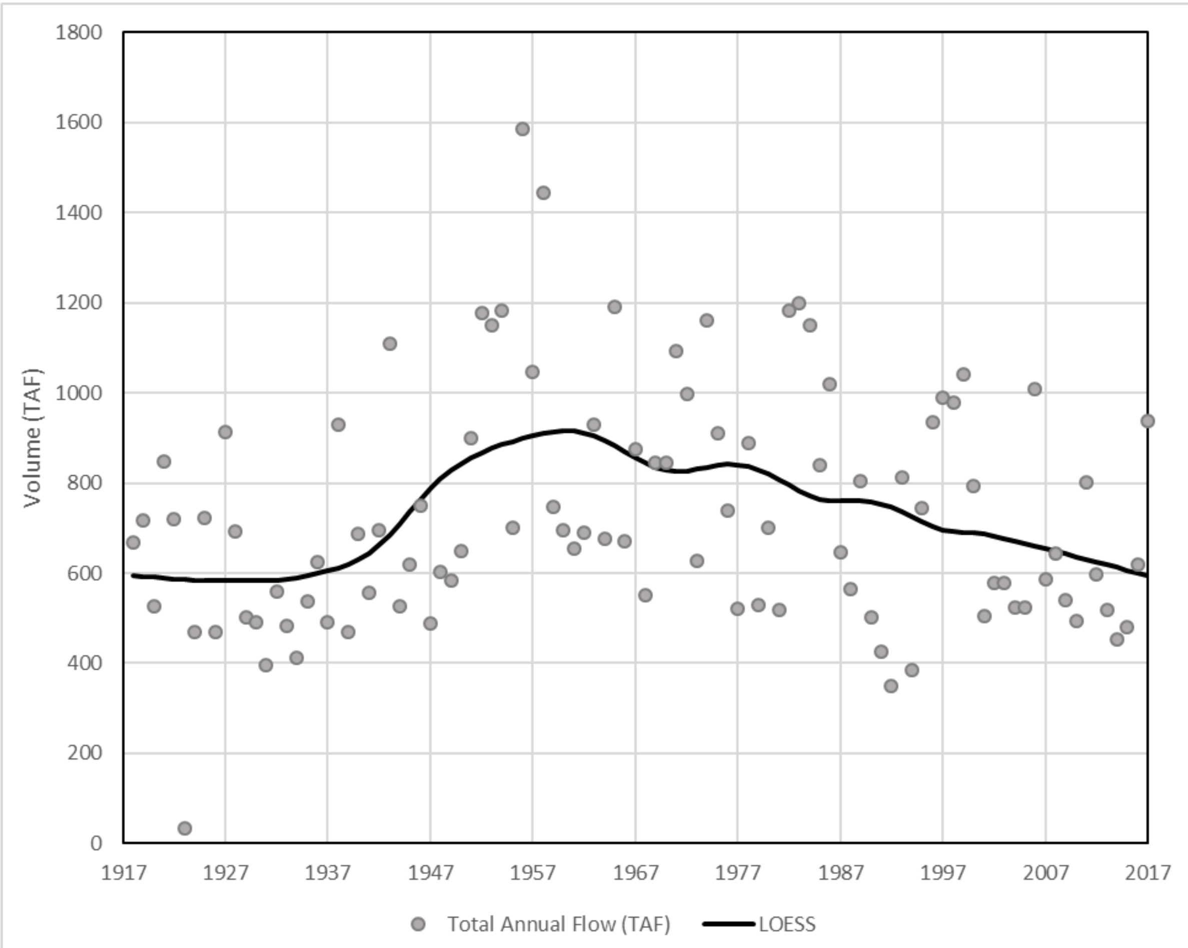


Figure 6-5. Total volume recorded annually at USGS gage 11502500 Williamson River below Sprague River near Chiloquin, OR for water years 1918 - 2017 and a LOESS smooth of these data. Note the outlier year of 1923; a gage malfunction resulted in the loss of flow data from 10/1/1922 through 8/30/1923.

Flow volumes were at their lowest in the last century during the 1917 to 1937 period, with annual flow volume hovering around 600 TAF. A marked increase in flow volume occurred during the 1940s and peak Williamson flow volumes for the observed period occurred in the mid-1950s. Since this time, a general downward trend has been observed. In the last decade, flow volume has trended toward levels not seen since the driest period on record. Also of note is the persistence of hydrologic trends across the period of record. Flow trends do not alter rapidly.

The most rapid change observed was the ascendant arc of flows from lows in the 1930s to peak values in the mid-1950s; this change manifested over the course of 20 years. The current downward trend has lasted approximately 50 years.

The Williamson River, which includes flows from the Sprague and Sycan Rivers, constitutes approximately half of the total inflow to UKL, making it a reasonable proxy for UKL inflow (Perry et al. 2005 pp. 24, 32, Stannard et al. 2013 pp. 3, 21). Additional inflow sources are the Wood River, Cascade Mountain snowmelt runoff via streams and subsurface throughflow, and numerous springs and groundwater seeps. These additional sources of inflow have short or nonexistent periods of recorded flow and are unlikely to increase in magnitude by enough to make up for any shortfall in Williamson River contribution. Figure 6-5 illustrates the past 100 years of recorded Williamson flows and points to several trends. Currently, Williamson River flow volume indicates an ongoing 50 year decreasing trend. This trend is unlikely to alter significantly in the next 5-10 years. Assuming that Williamson River flow volume is indicative of overall UKL inflow, this suggests that UKL inflow is also likely to trend downward for the next decade.

In addition to indicating trends in UKL inflow, the Williamson River flow volume may also be a bellwether for overall hydrology across the Upper Klamath Basin. The downward trend in Williamson River flow volume may be a symptom of drier hydrology: less precipitation, lesser and more ephemeral snowpack, and less interannual groundwater recharge. Data from Clear Lake and Gerber Reservoir show similar trends. Though these are water surface elevations from reservoirs, they also point to a recent period of interannual decline in basin-wide hydrology.

Clear Lake is a large, shallow lake situated south and east of UKL, within the closed Lost River basin. It was dammed and enlarged beyond its historic footprint by the Bureau of Reclamation in order to act as an evaporative lake and reservoir, removing water from the Lost River system in times of high flows and providing irrigation water in the spring and summer. Clear Lake has a single major tributary, Willow Creek, with a short period of recorded flow (since 2012). Likewise, Gerber Reservoir, the only true reservoir managed by the Klamath Project, is utilized for storage and delivery of irrigation water. Gerber Reservoir was created by impounding Miller Creek, an ungaged stream. Both of these reservoirs, though very different from the Williamson River, show signs of drier hydrology in recent years.

Lake surface elevation data for Clear Lake and Gerber Reservoir were provided as end of month values by the U.S. Bureau of Reclamation Klamath Basin Area Office. These monthly data were averaged to an annual mean value for their respective periods of record. A LOESS trend line was fitted to the data. The pattern of the trend line for Clear Lake surface elevation shows broad similarity to the Williamson River flow volume data (Figure 6-6). A period of low surface elevations accompanies the drier 1920s and 1930s, followed by a general rise in surface elevations coinciding with wetter conditions through the 1940s and 1950s. Clear Lake shows relative stability with a gradual increasing trend through the late 1970s. Thereafter, average annual Clear Lake surface elevations exhibit a gradual downward trend that steepens noticeably in 1993.

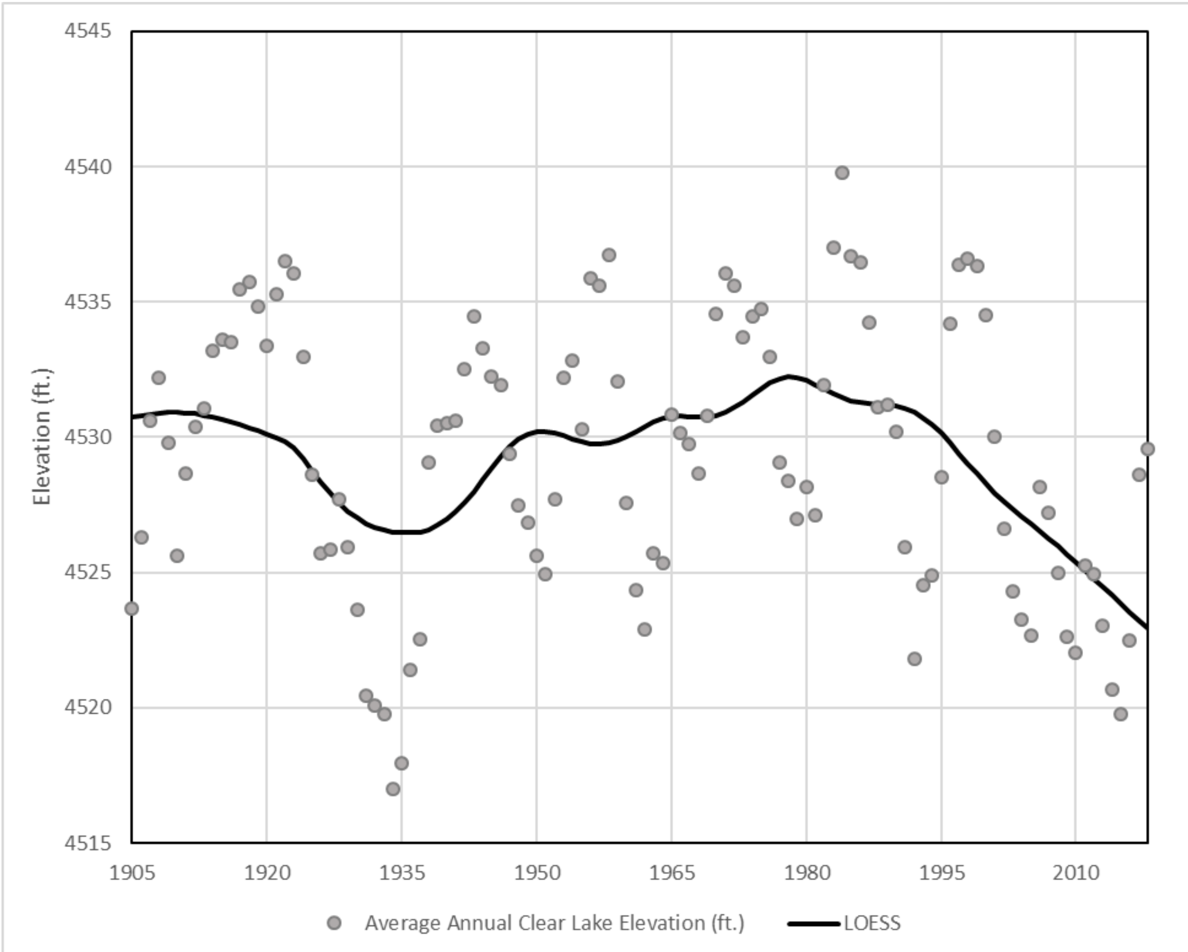


Figure 6-6. Average annual Clear Lake surface elevations for water years 1905 – 2018.

Gerber Reservoir surface elevations show less obvious similarity to the Williamson River, though this is likely due to it being a true reservoir and being operated as such (Figure 6-7). The hydrologically dry period during the 1920s and 1930s show a steady increase in reservoir storage, as might be expected during drought. A decline in the 1950s indicates less need for stored water and the need to maintain freeboard for additional flood storage. Surface elevation then increases through the 1970s and stabilizes through the 1990s. However, there is a marked and steep decrease in annual surface elevations beginning in 2003 and continuing through the present. Though this decline in Gerber Reservoir surface elevations differs in timing and duration from those observed in Clear Lake and the Williamson River, it nonetheless indicates a current period of drier hydrology and declining water storage.

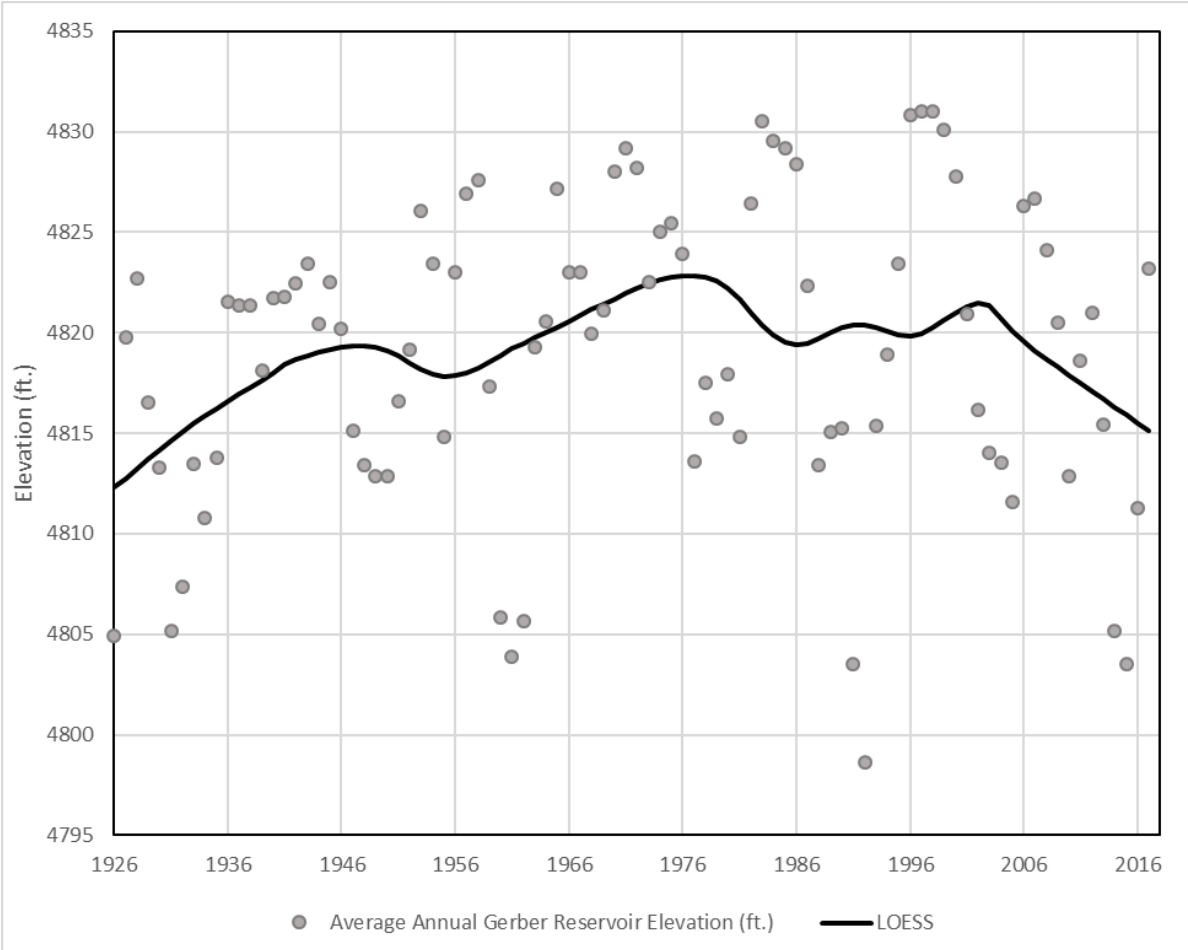


Figure 6-7. Annual average Gerber Reservoir surface elevations for water years 1926 – 2018.

Consideration of data from across the Upper Klamath Basin for the last century or more points to the likelihood of a continuing trend of drier hydrology for the next 5-10-year period. The Williamson River, Clear Lake, and Gerber Reservoir have all experienced the effects of declining flows for at least the past decade, if not longer. Even if these trends begin to alter in the near term, hydrologic evidence suggests that this alteration will not occur rapidly enough to have a significant impact on hydrology in the next decade. The data indicate that planning for continued dry hydrology, with the possibility of increasingly dry conditions, is warranted.

Of note for this discussion is the impact of climate change on future hydrology. Climate change and its impacts are very difficult to predict, with models returning widely varying results as to the timing and magnitude of precipitation and runoff and the changes in temperature. However, there is general agreement that temperatures will increase, particularly in summer months (Barr et al. 2010 p. ii, 20, 24). This is likely to result in increased evapotranspiration and greater demand on water supplies during irrigation seasons. It also appears likely that there will be a shift in the ratio of winter precipitation types, with a greater proportion of precipitation falling as rain rather than snow (USBR 2016 p. 6). This is likely to increase winter runoff and decrease snowmelt percolation through the system into the spring months, further stressing water supplies in a basin with limited interannual storage. These impacts are likely to be felt over the next 20 – 50 years, though it is unclear how quickly these changes will manifest. While the full effect of climate change may be unknowable at this time, climate modelling suggests that it would be prudent to plan for a system with hydrology that may be significantly altered from what has been observed in the past.

6.5.3 Water Quality

Water quality is a complex and important factor for sucker survival and vigor. Many elements contribute to water quality including temperature, dissolved oxygen, ammonia toxicity, pH, algae, and nutrient loading. Varied levels of detail are available on the ways in which these parameters may affect suckers. To date, no analysis of empirical data has detected a strong correlation between lake elevation and the relevant water quality parameters (e.g., Morace 2007, entire, see section 8.3.1.6 for a more thorough discussion). To provide a general understanding of how these water quality elements and suckers interact, we summarize the elements and provide sources for additional information, as appropriate.

6.5.3.1 *Blue-green Algae*

Blue-green algae, such as AFA, are relevant to the sucker environmental baseline because the massive annual bloom and subsequent crash dynamics are the primary driver of most water quality dynamics in UKL and Keno Reservoir during the high stress period of the summer months. Summertime blooms of AFA dominate Upper Klamath Lake phytoplankton communities due to excessive phosphorus loading linked to watershed development. Similar phytoplankton dynamics in Keno Reservoir/Lake Ewauna are due to large populations and associated nutrients of blue-green algae imported into the system from UKL in summer. Nutrient and algae exports also influence downstream reservoirs, particularly two largest reservoirs (i.e., Copco 1 and Iron Gate) in the Klamath Hydroelectric Reach where algal concentrations increase capitalizing on the imported nutrients.

Algal toxins represent a potentially direct effect from blue-green algae to suckers in UKL, in particular microcystin, a liver toxin produced by the cyanobacterium *Microcystis aeruginosa*. Microcystin may enter suckers through the gut as they consume midge larvae containing the toxin. Due to the limited capacity of fish to detoxify microcystins, fish suffer from sub-lethal effects or succumb to the toxic effects of elevated microcystin concentrations. Because microcystin is relatively stable, persisting *in situ* for months, it potentially could accumulate in fish tissues and in aquatic biota. However, direct consumption of *Microcystis* in the laboratory did not have measurable effects on survival or fish health (B. Martin, USGS, personal communication November 15, 2017). Suggested references for additional information include, but are not limited to Boyd et al. (2002), Butler et al. (2009), Caldwell Eldridge et al. (2012), Gilroy et al. (2000), Kent (1990), Malbrouck and Kestemont (2006), National Research Council (2004), Sullivan et al. (2008), Roy-Lachapelle et al. (2017), and VanderKooi et al. (2010).

6.5.3.2 *Dissolved Oxygen*

Dissolved oxygen (DO) concentrations within water depend on several factors, including water temperature (colder water absorbs more oxygen), water depth and volume, atmospheric pressure, salinity, and the activity of organisms that depend upon dissolved oxygen for respiration. Dissolved oxygen available for respiratory consumption by suckers is strongly influenced by the bloom and crash dynamics of algal communities, which in turn depend largely on availability of nitrogen and phosphorus. Within UKL, low DO concentrations occur most frequently in August, the period of declining algal blooms with associated decomposition and warm water temperatures in the lake. Downstream in Keno Reservoir, DO typically reaches very low levels from July through October as algae transported from UKL settle out of the water and decay; these low-DO events can last for extended periods. 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. Low DO does not appear to be a major threat in Clear Lake and Gerber Reservoir. Suggested references for additional information include but are not limited to Boyd et al. (2002), Jassby and Kann (2010), Kirk et al (2010), Martin and Saiki (1999), Morace (2007), Sullivan et al. (2009, 2011), and Walker (2001).

6.5.3.3 *Ammonia Toxicity*

Low DO events are often associated with high levels of un-ionized ammonia, which can be toxic to fish. Ammonia toxicity is complex because it is a function of total ammonia nitrogen concentration, pH, and temperature. The toxic form, ammonia, is most prevalent at higher pH. Ammonia concentrations in UKL can be high enough to threaten suckers (Burdick et al. 2015a p. 6). 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. These degraded conditions can occur throughout much of the 20-mile long reservoir, with better conditions only in the uppermost and lowermost reaches. Suggested references for additional information include Deas and Vaughn (2006), Kirk et al. (2010), Lease et al. (2003), Martin and Saiki (1999), Meyer and Hansen (2002), Saiki et al. (1999), Sullivan et al. (2011), and USEPA (2013).

6.5.3.4 *pH*

In the Upper Klamath Basin, summertime pH levels are elevated above neutral. Extended periods of higher pH are associated with large summer algal blooms in UKL. 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. Suggested references for additional information include, but are not limited to Aquatic Science Resources (2005), Boyd et al. (2002), Jassby and Kann (2010), Kann (2017), Lease et al. (2003), Martin and Saiki (1999), Morace (2007), Saiki et al. (1999).

6.5.3.5 *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. Both UKL and Keno Reservoir/Lake Ewauna may undergo periods of intermittent, weak summertime stratification, but water temperatures in these water bodies are predominantly similar throughout the water column. Clear Lake typically exhibits slightly higher temperatures than UKL. Although maximum water temperatures do not typically exceed the acute thermal tolerance of endangered suckers in either lake, they may cause stress to suckers in the hottest months leading to reduced growth and/or increased susceptibility to other stressors. Increasing temperature has many potential indirect 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. Suggested references for additional information include, but are not limited to Jassby and Kann (2010), Kirk et al. (2010), Flint and Flint (2012), Martin and Saiki (1999), Morace (2007), and Kann (2017).

6.5.3.6 *Nutrients*

Concentrations of primary plant nutrients, including nitrogen and phosphorus, in lakes are affected by the geology of the surrounding watershed, upland land uses, and physical processes within the lake and its tributaries. The ability of riparian and floodplain habitats to retain or alter nutrients throughout the system is degraded as a result of ditches, dikes, and levees that promote drainage or prevent overbank flows. UKL was eutrophic prior to settlement by Anglo-Americans but is now hypereutrophic due in large part to human modifications to the environment. The relatively high levels of phosphorus present in the Upper Klamath Basin’s young volcanic rocks and soils are a major contributor to phosphorus loading to the lake. Land use within the watershed increases inputs through soil erosion, pasture runoff, and irrigation return flows. UKL is a major source of nitrogen and phosphorus loading to the Klamath River, primarily due to nitrogen fixation by AFA. 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 Keno Reservoir and Klamath River below. Suggested references for additional information include, but are not limited to Boyd et al. (2002), Bradbury et al. (2004), Colman et al. (2004), Eilers et al. (2004), Kann and Walker (1999), Kirk et al. (2010), Kuwabara et al. (2007), National Research Council (2004), Snyder and Morace (1997), and Sullivan et al. (2009).

6.5.4 Die Off Events

Large fish die-off events, although uncommon, can have a pronounced effect on population resiliency by killing numerous individuals. Typically, adults have been the only life stage encountered during sucker die-offs in UKL, but it is likely any juveniles present would also be impacted but remain undetected because of their smaller body size. For example, three consecutive fish die-offs in UKL (1995–1997) possibly involved tens of thousands of adult suckers (Perkins et al. 2000a p. 10). 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. 2000a pp. 16–19, 24–29). During the die-off period in 1996 there was concurrently a *Microcystis aeruginosa* bloom, which may have also been a contributing factor.

Other reported die-offs in UKL include 1986 (Coleman et al. 1988 p. 5). Since the die-offs of the late 1990s, such events have been relatively rare with observations of sucker die-offs in 2003 and 2017. During August and September of 2017, 490 LRS and 9 SNS carcasses were observed, predominantly in the northwest area of UKL (M. Buettner, The Klamath Tribes, personal communication, January 2, 2018). The data are not sufficient to conclusively implicate low DO concentrations as the primary factor, but the highest numbers of carcass detections were coincident with the lowest DO levels of the summer, as occurred in each of the late-1990s events. It is possible that other die-off events went undetected or are under-reported in the literature. Nevertheless, it seems that widespread die-offs in UKL have occurred in roughly 1 out of 10 years.

6.5.5 Genetic Introgression

Hybridization is a single interbreeding event between individuals of two species. Introgression is the subsequent incorporation of genetic materials into the genome of the species as a result of numerous hybridization events (i.e., back crossing). Introgression is common among suckers in general and well documented among the Klamath Catostomids, particularly between SNS and Klamath largescale sucker (KLS; *Catostomus snyderi*) (Dowling et al. 2016 p. 3).

Hybridization and introgression between shortnose sucker and Klamath largescale sucker is well documented and evidenced by phenotypic intermediates in morphology (Markle et al. 2005 p. 476) and lack of discrimination among molecular markers (Dowling et al. 2016 p. 19). However, morphological distinctiveness of the species varies by location (Markle et al. 2005 p. 476), and the two species' spawning is partially isolated temporally and spatially (Markle et al. 2005 p. 480). In UKL, morphological attributes of both species are more or less maintained, while other populations such as Gerber and Clear Lake reservoirs show a spectrum of morphological intermediates (Dowling 2005 pp. 21–22).

Genetic diversity is lower for both species in Clear Lake Reservoir as compared to conspecifics in UKL. In this reservoir, both species have lower heterozygosity and allelic richness compared to conspecifics in UKL (Smith and VonBargen 2015 p. 24). Lower genetic diversity could be due to the population being derived from a limited number of individuals trapped when the dam was installed (i.e., founder effects) or simply due to genetic drift associated with small population size. Additionally, lack of connectivity with other populations also further depresses genetic diversity via reduced gene flow. Of more importance, the shortnose sucker population in Clear Lake Reservoir is highly introgressed with Klamath largescale sucker (Tranah and May 2006 p. 313, Dowling et al. 2016, entire). Shortnose sucker are more genetically similar to Klamath largescale within the same subbasin than they are to conspecifics from the other subbasin (Smith and VonBargen 2015 p. 14), in the Lost River subbasin, shortnose sucker and Klamath largescale sucker can be difficult to distinguish morphologically. This can potentially erode species distinctiveness (genetic representation) within the population as well as reduce the abundance of phenotypic shortnose sucker (i.e., abundance of individuals that possess the morphology associated with shortnose sucker) and thereby reduce population resilience. Genetic representation within the Gerber Reservoir population is very similar to that of Clear Lake Reservoir. The shortnose sucker are highly introgressed with Klamath largescale, and the population is completely disconnected from other populations.

Unlike the shortnose sucker, hybridization and introgression involving the endangered Lost River sucker does not appear to be extensive (Dowling et al. 2016 p. 18). At present, both endangered suckers in UKL are characterized by population sizes large enough to maintain genetic diversity and prevent the negative effects of inbreeding. We cannot make similar conclusions about other populations because we lack accurate estimates of population sizes.

The draining of Tule Lake and Lower Klamath Lake and the construction of dams and irrigation structures has isolated the populations such that there is no exchange of individuals between the major remaining populations in UKL, Gerber Reservoir, and Clear Lake, and the system no longer functions as a metapopulation. This reduction of redundancy and connectivity could also have negative impacts on representation of diversity within the species.

Maintenance of ecological and phenotypic distinction between shortnose sucker and Klamath largescale in UKL suggests that introgression between these species does not threaten the resiliency of that shortnose sucker population. However, the resiliency of the shortnose sucker populations in Clear Lake Reservoir and Gerber Reservoir may be compromised by dilution of the distinct genetics and ecology of the species through hybridization and introgression.

6.5.6 Harvest

Migrating suckers were a historically important food source for the Klamath Tribes and were harvested in large numbers during the spring months (Bendire 1889 p. 444, Evermann and Meek 1897 p. 60). Settlers of European descent also utilized sucker migrations as a source of food and fish oil, including some commercial harvest. Historical accounts of sucker harvest from the late 19th century describe a large fishery on the Lost River for fish migrating upstream from Tule Lake (Bendire 1889 p. 444, Gilbert 1897 p. 6). The construction of dams on the Lost River and the draining of Tule Lake for agricultural purposes eliminated this fishery. However, a large recreational fishery for suckers developed in the Williamson and Sprague Rivers. In 1967, the Klamath Falls fisheries agent for the Oregon Fish and Game Commission was quoted in the newspaper as stating, "we've estimated that about 100,000 pounds—that's 50 tons—of mullet [suckers] were snagged out of the two rivers in a three-week period" (Cornacchia 1967, entire). This snag fishery, which targeted primarily LRS but included SNS (Bienz and Ziller 1987 p. X), existed in the Williamson and Sprague Rivers up to 1987 when the Oregon Fish and Game Commission outlawed harvest of both species.

Until 1987, fishing pressure during the spawning migration likely contributed to population declines in Lost River and SNS in the Williamson and Sprague Rivers, but the magnitude of the effect is difficult to discern due to a lack of data on population sizes and harvest quantities during most of the 20th century. At present, some Lost River and SNS are inadvertently captured while anglers target other species in UKL; however, the numbers are likely small, and anglers are required by law to immediately release the fish.

6.5.7 Climate

The climate of the Klamath basin is classified by the Köppen-Geiger system as temperate with dry, warm summers, also known as a warm-summer Mediterranean climate (Peel et al. 2007 p. 1639). With this climate most of the precipitation falls in the form of snow during the winter. The climate of the Klamath Basin naturally fluctuates between wet and drought periods over a scale of years to decades. Droughts are of particular interest because of their influence on lake and reservoir elevations, which can affect suckers in a variety of ways (see section 8).

The years 1992, 2001, and 2011 rank among the driest single years and 1990-1992 ranks among the driest 3-year periods in the past 120 years (Malevich et al. 2013 p. 17). For longer-term droughts (6-20 years), the decade of the 1930s ranks among the driest in nearly 500 years (Malevich et al. 2013 p. 17). It is unclear how longer-term droughts affect the species, but these have the potential of affecting population-level dynamics such as persistent reduction in spawning production or other broad habitat modifications.

6.5.8 Environmental Contaminants

Contaminants from agricultural application of pesticides or other industrial practices could have affected sucker populations. Some of these compounds can remain bioavailable in the environment for decades. However, specific data regarding the historic or modern effects of contaminants on individuals and populations of these species are very sparse and inadequate to draw any definitive conclusions.

Organochlorine pesticides, such as DDT, were used extensively in the Klamath Basin (particularly the Tule Lake Basin) from 1940 through 1960 (Eagles-Smith and Johnson 2011 p. 19). Acute mortality to fish from DDT usually occurs at very low levels of concentration (U.S. Environmental Protection Agency 1975 p. 41). Eggs are especially vulnerable because the compound tends to accumulate in fatty areas, such as egg yolks (U.S. Environmental Protection Agency 1975 p. 43). In 1988, 15 years after DDT was banned, the sediments near the mouth of the Link River possessed the highest concentrations of various organochlorine pesticides of a broad survey of 25 aquatic sites in the Upper Klamath basin (Sorenson and Schwarzbach 1991 p. 62). Similarly, samples of suckers at the Link River mouth and in UKL all contained organochlorines (Sorenson and Schwarzbach 1991 p. 64). We are unaware of data regarding subsequent trends of concentrations in suckers, but significant declining trends in concentrations in birds of the Klamath Basin suggest these lingering compounds are less prevalent since the 1980s (Eagles-Smith and Johnson 2011 pp. 1–20). An evaluation of modern pesticide use on Tule Lake National Wildlife Refuge concluded that the type and concentration of chemical applications were unlikely to harm suckers in Tule Lake (Haas 2007 p. 3).

The processing of lumber products also provided a potential source of relevant environmental contaminants over the last century. For example, a mill located at the confluence of the Williamson and Sprague Rivers operated for 70 years – closing in 1988 (Parker 2008 p. 9).

Contamination of the site included numerous petroleum-based chemicals, pentachlorophenal, metals, and dioxins (Parker 2008 p. 10), all of which are toxic to fish under certain conditions. Its location near the upstream terminus of the only sucker river spawning habitat for both species presented a possible risk if harmful chemicals leached into the hydrological system. Dioxins are especially harmful to eggs since they bind with fat and oils, such as the yolk. The site has been "cleaned" and remediated for human health objectives by removing most of the petroleum-based chemicals, pentachlorophenal, and decaying wood that was mobilizing toxic metals. The dioxins were buried under a layer of protective soil. A minimal survey for dioxins in the nearby rivers during the spawning season indicated that current levels were likely not harmful (S. Burdick, USGS, pers comm, October 25, 2018). Nevertheless, it is not clear whether what impacts this and other similar sites have affected sucker populations.

Mercury deposited from the atmosphere can be highly toxic to fish and wildlife when it is converted into methylmercury. Methylation is stimulated by repeated inundation and drying, which occurs in the wetlands around Upper Basin Lakes as well as on the lands of Tule Lake and Lower Klamath National Wildlife Refuges where lands are rotated between agricultural use and wetland habitat for waterfowl (Eagles-Smith and Johnson 2011 pp. 27–28). However, mercury concentrations measured in suckers and other fish from the Upper Klamath Basin in 1988-1989 were below the national average for all fish (Sorenson and Schwarzbach 1991 p. 41). Overall, there is not strong evidence that contaminants have contributed substantially to the decline of sucker populations in the Upper Klamath Basin.

6.5.9 Predation

LRS and SNS evolved with substantial predation pressure on larvae and juveniles from native fish species, including redband trout (*Oncorhynchus mykiss newberrii*), blue chub (*Gila coerulea*), and Tui chub (*Gila bicolor*), as well as predation pressure on all life stages from numerous bird species. Non-native fishes introduced to the system also potentially impact suckers through predation. Approximately 20 fish species were introduced accidentally or deliberately into the upper Klamath Basin. These comprised about 85 percent of fish biomass in UKL when the suckers were listed (Scoppettone and Vinyard 1991 p. 375, National Research Council 2004 pp. 188–189). The introduced fish species most likely to affect LRS and SNS are the fathead minnow (*Pimephales promelas*) and yellow perch (*Perca flavescens*). Additional exotic, predatory fishes found in sucker habitats, although typically in relatively low numbers, include bullheads (*Ameiurus* species), largemouth bass (*Micropterus salmoides*), crappie (*Pomoxis* species), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), and Sacramento perch (*Archoplites interruptus*) (Koch et al. 1975 p. 17, Logan and Markle 1993 pp. 27–29). These fish may prey on young suckers as well as compete with them for food or space (Markle and Dunsmoor 2007 pp. 573–577).

Fathead minnows were first documented in the Klamath Basin in the 1970s and are now the most numerous fish species in UKL (Simon and Markle 1997 p. 146). Laboratory experiments have demonstrated that adult fathead minnows prey on sucker larvae (Markle and Dunsmoor 2007 pp. 573, 576). In UKL, higher fathead minnow abundances were associated with lower sucker survival rates (Markle and Dunsmoor 2007 p. 576). Likewise, as indirect evidence, higher larval sucker survival rates were also associated with greater water depth and shoreline vegetative cover, habitat that helps larvae avoid predation (Markle and Dunsmoor 2007 p. 575). Nonetheless, suckers outgrow fathead minnow's gape limitation quickly, and spatial and temporal overlap with other non-native predators (such as yellow perch) may be limited.

Several species of birds can prey on LRS and SNS. Bald eagles frequent sucker spawning sites, such as Ouxy Springs and the Sprague River near the Chiloquin Dam site, during the spawning season. Pelicans (*Pelecanus erythrorhynchus*) and double-crested cormorants (*Phalacrocorax auritus*) can also target juveniles and adults. There are also numerous other species of piscivorous birds, including terns, grebes, and mergansers, that may prey on juvenile and larval suckers throughout their range. Avian predation can be responsible for mortality of at least 8.4 percent of juveniles and 4.2 percent of adults annually in Clear Lake (Evans et al. 2016a pp. 1261–1262). Predation on spawning adults may increase mortality rates of this life stage and alter behavior during this critical period. For example, predation on adults, or the threat of predation, at spawning sites may limit the amount of time spent on the spawning ground, affecting overall reproductive outputs. It is difficult to determine whether avian predation has increased or decreased relative to historic levels, but bird populations in general in the Klamath Basin have certainly declined from historic numbers. Overall, it is more likely that the absolute amount of predation has also diminished.

6.5.10 Disease and Parasites

Numerous types of diseases and parasites infect LRS and SNS, some of which are associated with morbidity and mortality. Infections can cause physiological stress, blood loss, decreased growth rates, reduced swimming performance, lower overwinter fitness, and mortality, especially in small fish (Marcogliese 2004, entire, Kirse 2010, entire). Additionally, parasites may provide a route for other infectious pathogens by creating a wound in the skin, or they can make fish more susceptible to predation by modifying their behavior (Robinson et al. 1998 pp. 605–606, Marcogliese 2004, entire).

The LRS and the SNS are hosts to various species of bacteria, protozoa, myxozoa, trematodes, nematodes, leeches, and copepods (Foott 2004 pp. 3–4, Janik 2017 pp. 6–7). These can infect the eye, gills, kidney, blood, heart, muscle, skin, and gut. Many of these are pathogenic and can be associated at times with morbidity in suckers (Foott 2004 pp. 3–5, Foott and Stone 2005 pp. 7–9, Foott et al. 2010 pp. 5–13, Burdick et al. 2015a pp. 36–39, Hereford et al. 2016 pp. 35–39).

It is likely that most of the parasites currently able to infect Klamath suckers share an evolutionary history with suckers, suggesting that it is unlikely that native parasites cause the annual loss of juvenile cohorts. It is possible that the advent of a hyper-abundant introduced species has also increased the number of parasite hosts in the system. This could then theoretically increase the total number of parasites in the system, which could increase the infection rates of suckers. Furthermore, *Lernaea cyrpinacae* (anchor worms) are likely introduced and consistently parasitize sucker juveniles (Janik et al. 2018 pp. 1678 & 1683). While it is clear that parasites and disease affect individual survival, we currently do not have enough information to assess accurately the degree to which these negatively affect sucker population survival and viability.

6.5.11 Consulted on Effects

Here we describe the effects of past and ongoing actions known to occur within the action area and which affected or are affecting LRS and SNS. The Service reviewed records of past and ongoing consultations and provides summaries of formal consultations that are most relevant in describing the environmental baseline for the subject action. In essence, those actions that did not affect or that resulted in discountable or insignificant effects are not included as part of this discussion, as those actions did not rise to the level of take. This does not mean that we did not consider the other actions as part of the environmental baseline, rather we opted to focus our written summary on those actions with higher potential to significantly affect the environmental baseline for LRS and SNS.

6.5.11.1 *The Klamath Project*

The Bureau of Reclamation manages several reservoirs in the upper Klamath Basin to provide water for the 250,000-acre Klamath Project, which was established in 1905 as the second federal water project in the nation. The Bureau of Reclamation consulted with the Service multiple times on the Klamath Project since 1991, including the current proposed action. As the proposed action is an ongoing action for water management in the Klamath Basin, the potential for effects from water management activities and its associated infrastructure to listed suckers is not entirely different between past and current consultations. The effects of the proposed action are described in section 8 of this BiOp. However, some of the past actions included aspects that resulted in adjustments on the landscape, and those elements are described here. The Service has authorized lethal and non-lethal take for all life stages of LRS and SNS as a result of past and ongoing activities associated with the Klamath Project.

The creation of physical structures that are part of the Klamath Project (e.g., dams, canals, diversion points, etc.) altered the nature of the habitat both upstream and downstream. For example, habitat below Clear Lake Dam no longer functions as a migration corridor for spawning individuals because of impassable barriers and does not provide optimal habitat for out-migrating larvae given the unnatural flow patterns through the system. Conversely, the habitat above the dam has changed from a system with a large vegetated wetland associated with open water prior to the dam to a nearly homogenous open-water system with few emergent plants in most years.

A number of conservation actions have been undertaken as part of Reclamation's project operations such as screening of irrigation diversions, installation of a fish ladder at Link River Dam, and assisted rearing of LRS and SNS. These actions and their effects are described below in the Conservation Efforts section.

6.5.11.2 *PacifiCorp HCP*

PacifiCorp finalized a Habitat Conservation Plan (HCP) for LRS and SNS in November 2013 (PacifiCorp 2013, entire) in accordance with section 10(a)(1)(B) of the ESA. In response to this plan, the Service conducted an intra-service consultation (08EKLA00-2013-F-0043) on the effects to suckers of the authorization of the plan.

The HCP addressed direct effects to suckers, including entrainment at project diversions, false attraction at Project tailraces, ramp rates, lake level fluctuations, migration barriers, loss of habitat, and water quality, as well as effects to sucker critical habitat (PacifiCorp 2013 pp. 43–58). Additionally, the Plan proposed the shutdown of the East Side and West Side facilities to reduce sucker mortality resulting from entrainment into the canals (PacifiCorp 2013 pp. 64–66). PacifiCorp established a Sucker Conservation Fund to support sucker conservation goals and objectives, and committed to continue support of the Nature Conservancy's Williamson River Delta Restoration Project (PacifiCorp 2013 p. 67). These commitments included $100,000 to the fund and annual funding of about $20,000 to the Nature Conservancy over the next 10 years, as well as in-kind costs to implement management actions and monitoring (PacifiCorp 2013 pp. 79–80).

Implementation of the HCP required an Incidental Take Permit from the Service under the ESA. PacifiCorp operations at numerous facilities along the Link and Klamath Rivers were covered. The permit called for authorization of lethal take of both species over the next 10 years, including 10,000 eggs, 66,000 larvae, 500 juveniles, and five adults. Additionally, harassment of 1,400,000 larvae, 6,700 juveniles, and 25 adults was included. However, much of the take was eliminated when PacifiCorp ceased operation of the East Side and West Side facilities. The Service determined that issuance of the Incidental Take Permit for the HCP was not likely to jeopardize the continued existence of the LRS or SNS and was not likely to destroy or adversely modify critical habitat for the species.

6.5.11.3 *Grazing*

The Bureau of Land Management and U.S. Forest Service consulted with the Service on the effects of grazing related actions to LRS and SNS. These grazing actions are outside the action area for the current proposed action, but they could have effects to the same individuals or populations because suckers migrate from the current action area into the action areas for these grazing actions during spawning. The most recent consultations on these actions are summarized below.

The Klamath Falls Resource Area of the Lakeview District Bureau of Land Management completed formal consultation with the Service in 2014 on the effects of grazing related actions to shortnose suckers (08EKLA00-2013-F-0023). The action described lethal and non-lethal adverse effects from changes to habitat suitability and displacement of individuals. The allotments and pastures consulted on are hydrologically connected to Gerber Reservoir and Clear Lake.

The Fremont-Winema National Forest completed formal consultation with the Service in 2017 on the effects of grazing related actions to shortnose suckers (08EKLA00-2017-F-0099). The action described lethal and non-lethal adverse effects from trampling and displacement of individuals. The allotments and pastures consulted on are hydrologically connected to Gerber Reservoir and Clear Lake Reservoir.

The Modoc National Forest completed formal consultation with the Service in 1996 on the effects of grazing related actions to Lost River suckers (1-1-96-F-57 and 1-10-96-F-35). The action described adverse effects from changes to various habitat attributes. The action area for this consultation is hydrologically connected to Clear Lake Reservoir.

6.5.11.4 *Highway 140 Widening Project*

The Western Federal Land Highway Division of the Federal Highway Administration, in cooperation with the Oregon Department of Transportation, has consulted on but not yet completed, the widening of a 5.6-mile section of Oregon State Route 140 (OR-140) between mile post 57 and mile post 63, located northwest of the city of Klamath Falls. Consultation will be completed in early spring 2019. Approximately 2 miles of the action area is located along the western edge of Howard Bay in Upper Klamath Lake and approximately 4 miles are upland of the lake. In addition, the Federal Highway Administration will construct a 10.4-acre wetland site located approximately 3 miles east (across the lake) from the southern end of the action area.

Widening OR-140 will include expanding existing travel lanes from 11-feet to 12-feet, widening road shoulder to 6-feet, realigning roadway, constructing new embankment along Howard Bay, constructing stormwater treatment features, and clearing and grubbing upland areas. Highway widening along Howard Bay requires adding fill material to the lake to construct new embankments and create minor realignments to the roadway. Fill material will alter approximately 9.7 acres of Lost River and shortnose sucker habitat. However, upon completion of the project the current shoreline will have a net increase of 60 linear feet of shallow water habitat. Effects to LRS and SNS are anticipated from to alteration to habitat structure, function, and diversity as well as exposure to construction-related disturbance, turbidity, and sedimentation. The wetland construction component of the project has the potential to restore natural wetland habitat functions and connectivity over the long-term by slowing down water currents and decreasing wave action. Best management practices and minimization measures will be implemented to reduce impacts to LRS and SNS.

6.5.11.5 *Scientific Research*

In 2018, the Service consulted (08EKLA00-2018-F-0065) on the effects to LRS and SNS of issuing scientific permits for the purpose of promoting recovery of the species under section 10(a)(1)(A) of the ESA. The consultation addressed purposeful take of the species using a variety of scientific collection techniques, marking, transport and relocation, and biological sampling. Take authorized as part of scientific research includes purposeful lethal take of 15 adults, 30 juveniles, 1,000 larvae, and 2,000 eggs. Additionally, non-lethal harm of 20 adults, 40 juveniles, 500 larvae, and 1,000 eggs was authorized. The Service considered the effects of the issuance of scientific permits (as currently proposed) on the reproduction, abundance, and distribution of the species, as well as how the aggregation of these effects will affect the overall survival and recovery of the species. The Service determined that the action was not likely to jeopardize the continued existence of the LRS and SNS, nor adversely modify the designated critical habitat of the species.

6.5.11.6 *Klamath Tribes Sucker Rearing*

Included in the programmatic consultation on the issuance of recovery permits for actions involving LRS and SNS (08EKLA00-2018-F-0065) is assisted rearing, which allows for the collection of up to 75,000 wild-hatched larvae from the UKL system. The Klamath Tribes established a rearing program in 2018, and the first collections under the program were performed in spring 2018. A total of 20,000 larvae from the UKL system were brought into captivity. This first cohort is currently in captivity with an anticipated release date in spring 2020. The current permit allows for collection of up to 20,000 larvae per year. Although the scale of releases and the specific of effects of this action are unknown at present, it may result in additional recruitment to populations of LRS and SNS in UKL.

6.5.12 Conservation Efforts

6.5.12.1 *Klamath Basin Sucker Rearing Program*

The Service started an assisted rearing program for Lost River and SNS in 2015 to supplement populations in UKL through augmentation. The primary target of the effort is SNS, but the lack of an effective way to identify live larvae and juveniles means that both species are collected and reared. In 2013, the Bureau of Reclamation agreed to fund such a program as a way to improve the environmental baseline of the species to minimize impacts to suckers that may result from Klamath Project operations with a 10-year target of releasing a total of 8,000 to 10,000 suckers with lengths of at least 200 mm. The Service funded expansion of the program and aims to collect around 20,000 larval suckers for assisted rearing in spring of 2019.

The program was designed to maximize retention of genetic diversity and maintain natural behaviors post-release as much as possible (Day et al. 2017 pp. 306–307). Larvae are collected as they drift downstream in the Williamson River, so no brood stock are maintained, and the effects of artificial breeding are avoided. Collection efforts are currently spread across the drift season to maximize the genetic variability. Juveniles are stocked into semi-natural ponds and growth depends on a combination of natural and artificial feed.

The first release of reared suckers into UKL occurred in spring 2018, and the proportion of released individuals that will join the spawning population is unknown. Thus, the assisted rearing program is likely to be a source of recruitment for both SNS and LRS in UKL, but the specific impact on population trajectories will be uncertain until information on survival and recruitment probabilities of released individuals is available. Support for the ongoing operation of this program is a component of the current proposed action.

6.5.12.2 *Habitat Restoration*

Numerous agencies and organizations have restored important components of habitat to reduce threats to these species over the last 20 years. In most instances, considerable time is necessary to determine the efficacy of such recovery actions because of the time needed for the habitat to achieve full functioning and the subsequent time needed for a long-lived species to respond with improved demographics. For example, actions to increase reproduction and recruitment into adult populations require at least 5 years for SNS and 9 years for LRS to achieve minimal functioning.

Hundreds of on-the-ground restoration projects, wetland, riparian, in-stream, upland, and fish passage projects have been implemented in the Upper Klamath Basin that directly or indirectly benefit suckers. Many of the projects included elements of more than one category of restoration project type taking a holistic or ecosystem approach based on the assumption that restoration of natural ecosystem functioning will ultimately benefit multiple species, including listed suckers.

Major sucker recovery-oriented projects completed include screening of irrigation diversions, eliminating barriers to fish passage, and restoration of rearing and spawning habitat (Table 6-1). For example, restoration of the Williamson River Delta by The Nature Conservancy, with substantial support from PacifiCorp and other organizations, has provided approximately 2,500 hectares (~6, 000 acres) that can serve as rearing habitat for the largest spawning populations of both species despite much of the area being deeper than it was historically due to subsidence. The removal of Chiloquin dam in 2008 opened approximately 120 kilometers (75 miles) of potential spawning and migration corridor. Additionally, screening the A-canal in 2002 reduced entrainment of fish greater than 30 millimeters (1.2 inches) into the irrigation systems of the Klamath Project canal system. Prior to placement of the screen, up to hundreds of thousands of juveniles were estimated to be entrained into the irrigation canals at this point each year (Gutermuth et al. 2000a p. 14). In addition to these major accomplishments, private landowners, the Oregon Department of Fish and Wildlife, Bureau of Reclamation, Natural Resources Conservation Service, the U.S. Fish and Wildlife Service, have realized countless other smaller projects that can benefit LRS and SNS populations.

Table 6-1. Summary of some recent major restoration projects benefitting Lost River sucker and shortnose sucker populations. Many of these projects were cooperative efforts of state and federal agencies, non-profit organizations, and private landowners.

Project	Year Completed	Potential Benefits
Reducing Entrainment		
A-Canal Screen	2002	Retain more larvae and juveniles in Upper Klamath Lake by limiting entrainment into the canal
Clear Lake Dam Screen	2003	Retain more larvae, juveniles, and adults in Clear Lake Reservoir by limiting entrainment into the canal
Modoc Irr. Dis. Williamson River Div. Screen	2007	Reduce larval mortality due to entrainment
Geary Canal Screen	2009	Retain more larvae and juveniles in Upper Klamath Lake by limiting entrainment into the canal
Eliminating Barriers		
Link River Dam fish ladder	2004	Restore connectivity of sucker populations in Upper Klamath Lake and Lake Ewauna by allowing for adult passage upstream, which may then contribute to spawning populations.
Chiloquin Dam removal	2008	Opening 120 km (75 mi) of historic migration, rearing, and spawning habitats in the Sprague River
Providing Habitat		
Williamson River Delta restoration	2008	Provide ~2,500 hectares (6,000 acres) of potential rearing habitat for larvae and juvenile suckers in Upper Klamath Lake

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

7.1 Analytical Approach

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

The following analysis relies on the findings presented in the *Status and Environmental Baseline of the Lost River Sucker and the Shortnose Sucker* 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.

The primary purpose of the proposed action is storage and delivery of water for Project uses; as such, 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 5-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 water years 1911–2018 and 1925–2018, respectively; however, the analysis for each of these reservoirs gives more weight to conditions observed over the last few decades, which are more likely to be representative of conditions over the term of this BiOp. The POR hydrological data set for UKL relied upon in this analysis is the 36 years between October 1, 1980, and September 30, 2016. 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. The most recent full water years of 2017 and 2018 are excluded because development of the KBPM occurred during these years, and their inclusion was infeasible due to the need for data updates and associated re-balancing of model parameters. 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.

Other water bodies are used primarily to pass water through, such as Keno Reservoir, or serve as a catchment for return flows, such as Tule Lake. These water bodies are managed in relatively narrow depth ranges that depend less on hydrologic conditions. Because of the reduced variability, the effects analysis does not depend on hydrologic conditions in an observed period of record but simply the specific reservoir elevations and operations in the proposed action.

7.1.2 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 Service 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 Service 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. A similar 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 2018a, Appendix 4A) and the description of the proposed action in the BA and in this BiOp.

Note that on February 15, 2019, the Service received an addendum to the BA from Reclamation that included, amongst other items, the provision of additional releases from UKL to support enhanced May/June flows in the Klamath River (*see* Section 4.2.2.3.3.5 for additional detail).

This additional release will support habitat for listed coho salmon. This effects analysis is based upon KBPM output data that includes these additional releases and fully considers their implications for listed suckers.

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 such an 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:

- Higher frequencies of dry conditions than observed in the period of record that result in greater adverse impacts to suckers
- Declines in base flows during the July through September period could lead to lower late summer and fall lake elevations.
- Continued shifts in the timing of spring run-off earlier in the year could extend the declining limb of the lake hydrograph across a longer season and lead to lower summer and fall lake elevations.
- Shifts in the pattern of consumptive water use within the Project or increases in water use upstream of 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 5-year consultation term (April 1, 2019, to March 31, 2024). However, we are also aware that if trends continue, climate may be somewhat drier on average during the next 5 years than for the entire POR because drier conditions have prevailed recently.

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 exponentially smoothed net inflow (KBPM SV file variable I1)
- 60-day trailing average of UKL inflow (KBPM SV file variable UKLInf_60Avg)
- Normalized index of cumulative UKL inflow (KBPM SV file variable UKL_Cum_Inf_Ind)
- Cumulative precipitation index (KBPM SV file variable Cum_Ppt)
- Williamson River daily average flow (KBPM SV file variable Will_Riv_Inf)
- 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 UKL
- Project and Lower Klamath NWR daily diversions and return flows

7.1.3 Scope of Hydrologic Conditions Expected under the Proposed Action

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. 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 5-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 5 years) and, therefore, we assume rare events in the past will be rare in the near future.

To ensure that the conditions observed during implementation of the proposed action remain within the scope of this effects analysis, we define a number of boundary conditions. Due to the variable nature of hydrologic conditions, we define boundary conditions using both absolute conditions and frequencies. We do not expect these conditions to be exceeded, and if they are, USFWS considers the effects of the proposed action beyond the scope of what has been analyzed here. These conditions, which are further explained in later sections, are:

- Two consecutive years in which UKL surface elevations fall below 4142 in April or May
- UKL surface elevations below observed elevations in 2010 in April or May
- UKL surface elevations below 4,138.26 ft (1,261.36 m) at any time
- More than one water year when UKL surface elevations drop below 4,138.5 ft (1,261.4 m) at any time

- Any year with UKL surface elevations less than 4,140.0 ft (1,261.9 m) by July 15, more than 1 year when surface elevations fall below 4140.5 ft (1,262.0 m) by July 15, or more than 2 years when surface elevations fall below 4140.8 ft (1,261.1 m) by July 15

Each of these boundary conditions is directly related to anticipated effects of the proposed action on LRS and SNS that are analyzed below, so exceeding them is expected to have greater effects than what has been analyzed in this BiOp.

7.2 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.
- 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 and Gerber Reservoir will be operated within the historical 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 (1,260.67 m). 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.
- 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 5-year consultation term (April 1, 2019–March 31, 2024).
- Reclamation will provide the staff and funding necessary to implement the conservation measures proposed in the BA.
- 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 (USBR 2018a pp. 4–28 & 4–29).

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 their habitat. For ongoing water projects, such as the Klamath Project, determining the effects of the Proposed Action on listed species and their habitat is complicated. Project-affected lakes and reservoirs experience varying water levels and water quality conditions as a result of Project-related discretionary management actions, unrelated natural and man-caused changes in inflows and outflows, and pre-existing infrastructure that have collectively altered the 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, Project operations are expected to result in higher water levels and the quantity and quality of sucker habitat in Project lakes and reservoirs in the spring and lower in the summer, 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.

7.3 Effects of the Proposed Action to LRS and SNS Populations in the UKL Recovery Unit

The Revised Recovery Plan for the LRS and the SNS (USFWS 2013a) identifies two recovery units for both species: (1) the UKL recovery unit; and (2) the Lost River sub-basin recovery unit (See Section 6.4.2). 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. We have organized the effects analysis by recovery units because the effects of the action tend to be similar within recovery units and because the Klamath project is managed differently in the two recovery units.

7.3.1 Effects of the Proposed Action to LRS and SNS in UKL

The UKL recovery unit for the LRS and the SNS consists of Upper Klamath Lake, its tributaries, and the reservoirs along the Klamath River. The proposed Project operations are likely to affect habitat availability for most LRS and SNS life-history stages, including embryos, larvae, age-0 juveniles, older juveniles, and adults.

As described in the *Status of the Species* section 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 (See Section 6.2). 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. The analysis, and the supporting figures and tables, in this section focus on specific effects to LRS and SNS.

In order to reduce Project operation impacts to LRS and SNS in UKL, two specific measures were incorporated into the KBPM model during development of the PA and are reflected in the effects analysis. First, the UKL central tendency is a guideline for UKL elevations throughout each water year that is keyed to experienced hydrology (*see* Section 4.2.2.1 for further detail). This variable central tendency incorporates the needs of suckers and allows for reduction in releases from UKL in order to ensure that lake elevations meet or exceed the central tendency in most years. It is important to note that there are some time periods in the model POR when UKL elevations are below the central tendency; these conditions were analyzed as part of this effects analysis, and therefore simply dropping below the central tendency does not fall outside the effects analyzed here. Second, the UKL credit is a volume of water that may be stored in UKL to support spring lake elevations while also protecting end-of-water-year lake elevations from irrigation needs (*see* Section 4.2.2.1 for further detail). The credit accrues when spring return flows from Project lands are not re-diverted for Project needs but rather go downstream to support river releases. When this occurs, an equivalent volume of water is stored in UKL and accumulates throughout the irrigation season. This volume results in UKL elevations that may be temporarily elevated as the credit accrues, as well as providing a buffer to lake elevations against irrigation use throughout the season. Both measures are fully considered in the effects analysis.

7.3.1.1 *Effects to Shoreline Spawning Habitat*

A subset of LRS in UKL spawn at shoreline springs along the east side of the lake beginning as early as March and extending through May, with a peak in April (Buettner and Scoppettone 1990 pp. 17–19, Barry et al. 2007 pp. 18–28, Janney et al. 2009 pp. 7–8, Burdick et al. 2015b p. 484, Hewitt et al. 2018 pp. 10, 12). A recent study demonstrated that in 2010 low lake surface elevations resulted in less spawning activity at the shoreline springs (Burdick et al. 2015b pp. 487–488). In 2010, observed end-of-month lake elevations were 4140.49 in March, 4141.00 in April, and 4141.28 in May (Figure 7-1). There were 14% fewer females and 8% fewer males detected at the spawning sites in 2010 than in years with higher lake elevations. Individuals that were detected spent less time on the spawning grounds (36% less for females, 20% less for males) and visited fewer spawning areas (Burdick et al. 2015b pp. 483–484). The reduced spawning activity most likely resulted from reductions in the spawning habitat with suitable substrate, hydrology, and depth (Figure 7-1; Burdick et al. 2015b p. 483). The time that individual LRS spent on the spawning grounds was also reduced at low, but less extreme, elevations. Overall, these data indicate that lake elevations below 4,141.4 ft to 4,142.0 ft (1,262.3 m to 1,262.5 m) would result in adverse effects due to reductions to duration of spawning; reductions in both spawning duration and numbers are expected to occur at elevations comparable to observed conditions in 2010.

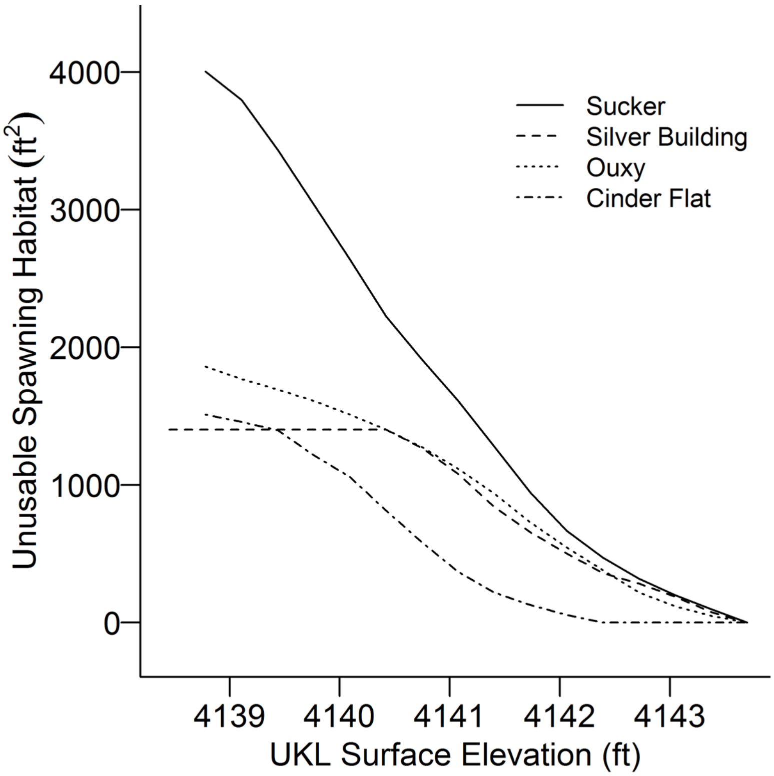


Figure 7-1. Area of unusable spawning habitat at the UKL shoreline springs at varying lake surface elevations (data from Burdick et al. 2015b p. 485).

Based on the KBPM output using POR data, UKL surface elevations at the end of March are at or above 4,142 ft (1,262.5 m) in 35 of 36 years (Figure 8.2). This equates to a probability slightly less than 3 percent that lake surface elevations are below 4,142.0 ft at the end of March, which is unlikely to occur during the 5-year term of this BiOp. The probability of lake elevations below 4,142 ft is 8% at the end of April (3 of 36 model years) and 11% at the end of May (4 of 36 model years), including one year that had an elevation of 4,141.96 ft (1262.49 m) at the end of May. One model year (1992) had lake surface elevation at or below the observed elevations in 2010, which occurred starting on April 29 in the model output and continued through the end of the spawning season (Figure 7-2).

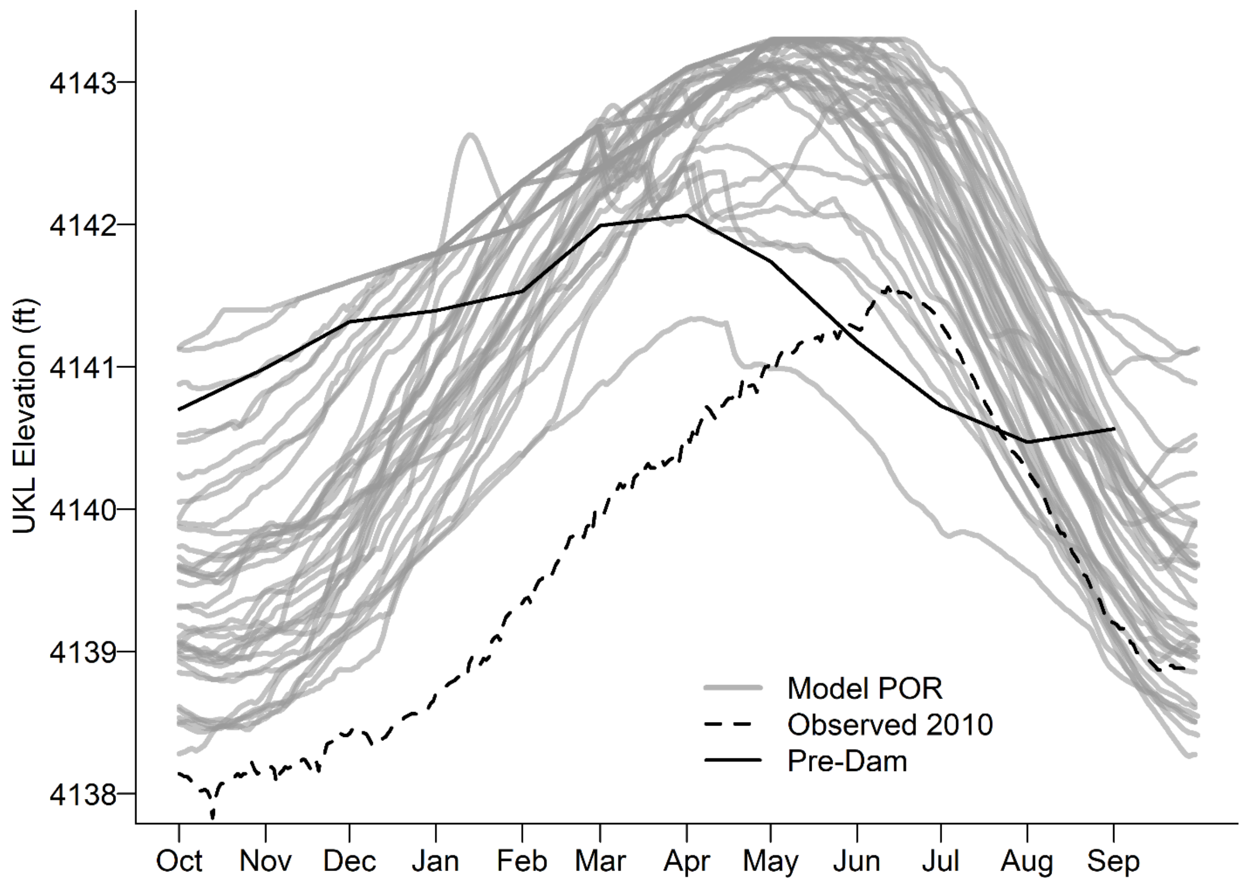


Figure 7-2. Modeled Upper Klamath Lake surface elevation for the proposed action period of record (gray lines), the observed lake surface elevation in 2010 when spawning at the shoreline springs was reduced by lake elevations (black dashed line), and the average end of month elevations prior to the installations of Link River Dam (1906-1921; black solid line).

Based on the above information, the USFWS concludes that the proposed action is likely to result in UKL elevations in March, April, and May during most years that 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 ft (1,262.5 m), which has an 11 percent probability of occurring in April or May and occurred in four out of 36 years in the model output, the proposed action is likely to adversely affect sucker spawning because of reduced habitat availability. Under hydrologic conditions similar to those that occurred in 1992, spawning could be considerably reduced because adults either do not spawn or they spawn in unsuitable habitat, which results in death of embryos or pre-swim-up larvae; these conditions are expected to be rare. The probability that conditions similar to 2010 are observed at least once within the 5-year term of the BiOp is 13%, and it is therefore unlikely to occur. The probability that lake elevations less than those observed in 2010 occurs at least twice in the 5-year term is 0.1% and is therefore discountable. The probability of at least one year with lake elevations below 4,142 ft (1,265.5 m) in the 5-year term is 45%, and the probability of at least two years below 4,142 ft (1,265.5 m) is 10%. Conditions similar to observed lake elevations in 2010 would be expected to reduce the number of females by 14% and the time that females spend on the spawning grounds by 36% (Burdick et al. 2015b pp. 483–484), which is likely to result in adverse effects due to reduced reproductive output. As described above, it is unlikely that these conditions will be observed during the 5-year term of this BiOp. Such conditions would not affect spawning in the Williamson River, and production of LRS and SNS eggs and larvae in UKL is still expected to be on the order of millions on an annual basis for the 5-year term of the proposed Project.

7.3.1.2 *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 a maximum of 3 weeks following spawning and fertilization (Coleman et al. 1988 p. 27). For example, 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 rapid decreases in lake elevation between egg deposition and larval swim-up. The minimum observed spawning depth for LRS is 0.6 ft (0.18 m) (Buettner and Scoppettone 1990 p. 20), so we would not expect any dewatering of embryos or pre-swim-up larvae unless there were surface elevation changes of greater than 0.6 ft within 3 weeks. Even with a decrease of 0.6 ft within 3 weeks, only eggs spawned at the shallow extreme of LRS spawning habitat would be affected. The maximum elevation decrease within 3 weeks of any date in March-May from the modeled POR was 0.7 ft. The maximum drop within 3 weeks of any March-May date was less than 0.45 ft in 95% of cases and less than 0.59 ft in 99% of cases (Figure 7-3). Thus, impacts to embryos and pre-swim-up larvae are expected to be exceedingly rare, and conditions are expected to provide for the annual production of millions of LRS and SNS larvae in UKL.

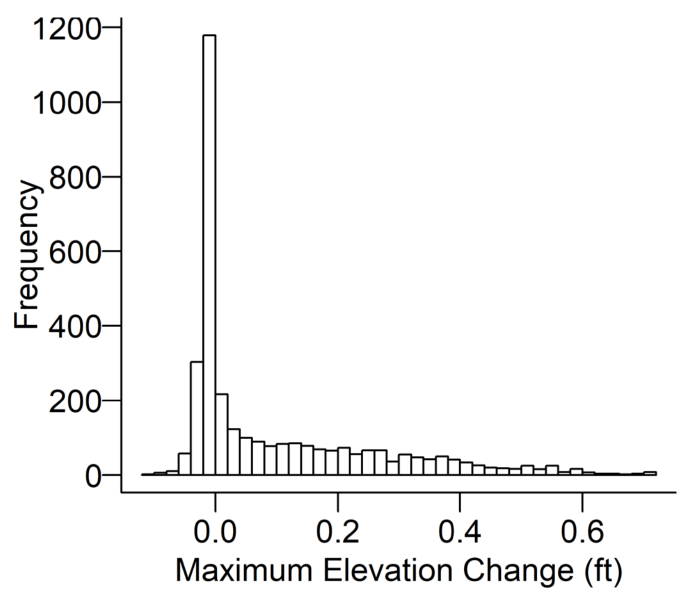


Figure 7-3. Frequency of maximum changes in UKL surface elevation within three weeks of potential egg deposition dates (all dates in March-May). Changes greater than 0.6 ft have the potential to dewater LRS embryos deposited at the shallowest observed spawning depth.

7.3.1.3 *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 (Cooperman and Markle 2003, Markle and Clauson 2006 p. 496). Although larval suckers use many habitat types, they are found at higher densities in shallow, nearshore areas with emergent vegetation (Cooperman and Markle 2004 p. 370). These vegetated areas likely provide larval suckers protection from predators (Markle and Dunsmoor 2007 p. 571), possibly more diverse food resources (Cooperman and Markle 2004 pp. 374–375), protection from turbulence during storm events (Tribes 1996 pp. 10–11), and hydraulic roughness that could reduce the numbers of larvae transported out of the lake by currents (Strayer and Dudgeon 2010). As larvae transform into juveniles in mid-July, the importance of emergent wetland habitat becomes less certain.

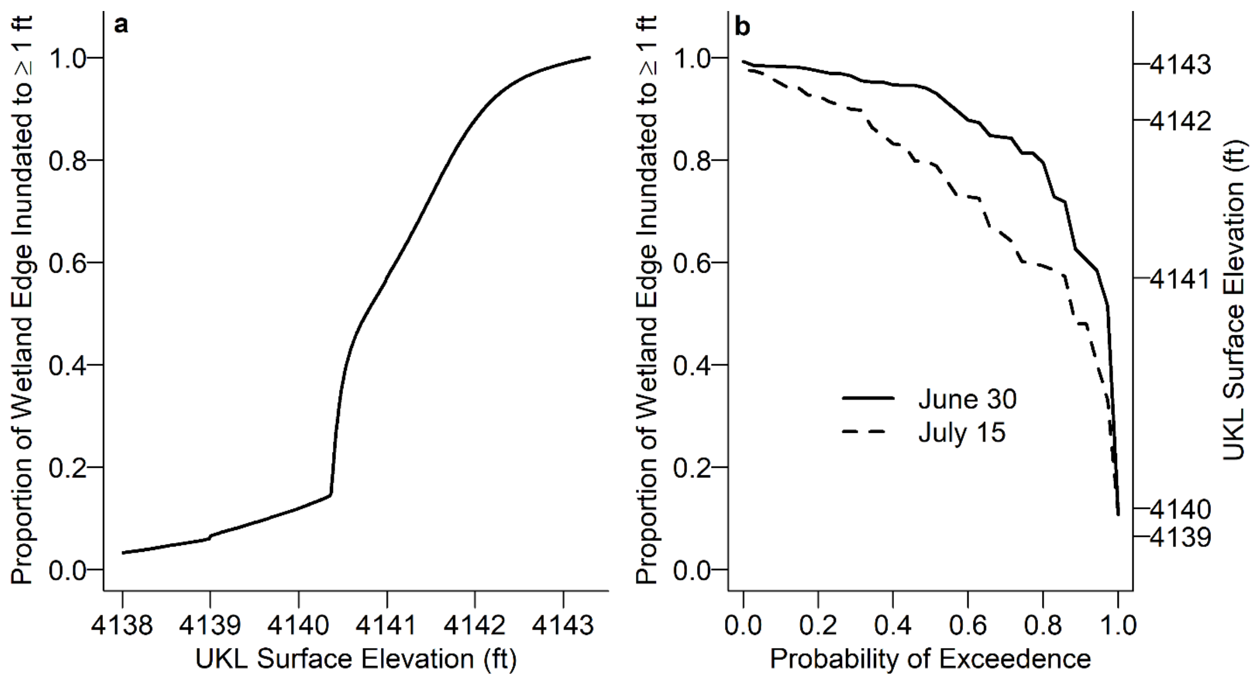


Figure 7-4. a) Relationship between UKL surface elevation and the proportion of emergent wetland edge habitat that is inundated to at least 1 ft (reproduced from Hereford and Roberts 2019 p. 9). b) The probability of exceedance for the proportion of emergent wetland edge habitat inundated to at least 1 ft on June 30 (solid line) and July 15 (dashed line) expected under the PA based on the model output from the period of record.

As UKL elevations decrease through the summer, so does the area of inundated emergent vegetation, so that at an elevation of 4,140.8 ft (1,261.1 m) approximately half of the emergent wetland habitat remains (Figure 7-4a). Thus, UKL elevation influences larval suckers' access to and use of nursery habitat (Dunsmoor et al. 2000, Terwilliger 2006 pp. 10–11, Markle and Dunsmoor 2007 p. 568). If the area of inundated emergent vegetation declines substantially, 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.

The lowest elevation at the end of June in the model POR was 4,139.85 ft (1,261.8 m), equating to 11% of wetland edge habitat inundated to at least 1 ft. On July 15, the lowest elevation in the POR was 4,139.79 ft (1,261.8 m), equating to just under 11% inundation. These minima both occur in the model year 1992. Because these conditions occur in just 1 of 36 in the POR, it is very unlikely that they will occur during the 5-year term of this BiOp. Less than 50% of wetland edge habitat was inundated on July 15 in the model POR in 5 of 36 years (14%). Thus, a majority of the potential habitat is expected to be available in most years. However, when less than 50% of wetland edge habitat is available at elevations below approximately 4,140.8 ft (1,262.1 m) larvae could be more vulnerable to entrainment at the outlet of the lake, predation, and starvation, though the specific effects are difficult to determine. Still, lake elevations are expected to provide sufficient larval rearing habitat in nearly all years, and the availability of rearing habitat anticipated under this action would not be expected to preclude recruitment of larvae to juvenile and adult life stages.

In addition to the potential adverse effects of reducing wetland inundation, variability in UKL surface elevations are likely to provide a beneficial effect by maintaining marsh habitats and potentially spurring marsh development. Variability is important for wetlands because flooding disperses seeds but germination is poor under water (Middleton 1999 pp. 99–133).

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 for 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, less than 50% of the potential habitat would be available when lake levels go below 4,140.8 ft (1,261.1 m) by July 15 (14% of years in the model POR).

As a note of interest, lake elevations would be expected to vary seasonally even without Project operations due to natural variation in inflows, making it difficult to tease apart the effects of the proposed action from the environmental baseline. For example, before the construction of Link River Dam (1905-1921), UKL surface elevations in mid-July ranged from 4,139.96 ft (1,261.88 m) to 4,141.66 ft (1,262.39 m), largely overlapping the range of conditions expected under the proposed action.

7.3.1.4 *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 habitats but appear to select for shallow water (Buettner and Scoppettone 1990 pp. 32–33, Burdick et al. 2008 pp. 425 & 427). Although some authors have reported movement of age-0 juveniles from nearshore areas to offshore areas as the lake elevation is nearing its annual minimum (Terwilliger 2006 p. 3), this pattern has not been supported by more recent juvenile sampling (Hendrixson et al. 2007 pp. 44, 59–60, Burdick et al. 2008 p. 427). Age-0 juveniles appear to use diverse habitats including vegetated and unvegetated areas and all substrates (Hendrixson et al. 2007 p. 14, Burdick et al. 2008 p. 424). There are conflicting reports on habitat selection with some studies providing weak evidence for the selection of sandy, vegetated habitats (Hendrixson et al. 2007 p. 14, Burdick et al. 2008 p. 424), rocky substrates (Terwilliger et al. 2004 p. 11), and mud or sand (Buettner and Scoppettone 1990 p. 30), but none of these studies has found a strong association between juvenile sucker distribution and vegetation or substrate type. In general, more complex habitat structure (e.g., vegetation or rocky substrates) is thought to provide more cover for fish, and it often increases growth or survival (Strayer and Findlay 2010 pp. 132–133). Additionally, water quality might differ among 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 pp. 7–8). In general, rocky substrates in UKL are found nearshore where sediments are swept away by waves and currents (Eilers and Eilers 2005 p. 31), and increased circulation and lower levels of organics in these substrates, rocky areas would be expected to increase DO relative to areas where mud predominates. Due to the uncertainty in habitat preferences and the influence of habitat availability on growth and survival, lake elevations that provide access to diverse habitats would be most protective of age-0 juvenile suckers.

Lake elevations in UKL influence habitat diversity and complexity. When lake levels drop below about 4,140.8 ft (1,262.1 m) around 50% of wetland edge habitat becomes dewatered, and below 4,139.6 ft (1,262.0 m) 90% of wetland edge habitats become dewatered (Figure 7-4a). 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 pp. 21–24, Eilers and Eilers 2005 p. 31). Thus, as lake levels recede below 4,139.6 ft (1,261.6 m), and especially below 4,138.0 ft (1,261.3 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. Lake elevations below 4,138.0 ft (1,261.3 m) are not expected under the proposed action; however, lake elevations below 4,139.6 ft (1,261.6 m) occurred in 1 of 3 years in the model period of record, indicating that habitat diversity for juvenile suckers is likely to be reduced in some years under this proposed action.

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

Data on older juvenile suckers in UKL are sparse, largely due to their scarcity. The data that are available suggest that juvenile habitat selection is more similar to that of adults than that of larvae (Burdick et al. 2009 p. 25, Burdick and Vanderkooi 2010 p. 13). Therefore we assume that older juvenile habitat needs are similar to adults, for which more data are available, in this analysis.

Radio-telemetry studies have shown that adult suckers primarily use the north end of UKL above Bare Island from June to September (Peck 2000 pp. 2–3, Banish et al. 2007 pp. 12–13, 2009 p. 159). During this period, adult suckers are found in open water areas of the lake, most frequently at depths greater than 10 ft (3 m), and they tend to avoid depths less than 6.6 ft (2 m); in general, LRS are found farther offshore than SNS (Peck 2000 p. 3, Banish et al. 2009 pp. 159–162). Neither LRS nor SNS adults were observed using depths less than 3 ft (1 m; Banish et al. 2007 pp. 10–11). 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 were distributed in the water column. However, neither species was found at depths greater than 25 ft (8 m; Banish et al. 2007 pp. 10–11). Depths up to about 40 feet (12 m) or more occur along the east side of Eagle Ridge.

To evaluate the availability of habitat within the preferred depth ranges of adult suckers we combined the model output for the POR with a bathymetry layer that combines data from multiple sources. We consider these bathymetry data as the best available information on the depth of UKL for the analysis of habitat (Shelly et al. 2019). We evaluated the area within relevant depth ranges available across varying UKL surface elevation and restricted the analysis to the northern third of the lake (north of latitude 24°24'47" N) inclusive of all of Ball Bay, Shoalwater Bay, and the Williamson River delta. The area was restricted based on radio-telemetry data demonstrating that LRS and SNS primarily use this area during the summer months (Banish et al. 2009 p. 159). As noted above, LRS and SNS appear to avoid depths less than 2 m (6.6 ft), and especially less than 1 m (3.3 ft), and primarily utilize water between 2 and 4 m (6.6-13.1 ft) during summer months (Banish et al. 2009 pp. 159–161).

Under the proposed action the lowest anticipated UKL surface elevation at the end of September under extremely dry conditions is 4,138.26 ft (1,261.36 m), which provides approximately 9,428 ac (3,815 ha; 33 percent) of available habitat in northern UKL at depths of 6.6 ft (2 m) or greater (Figure 7-5). Thus, there appear to be thousands of acres of potential habitat available during late summer and through the end of September even at the lowest lake elevations expected under the proposed action. Given the relatively low abundance of suckers in UKL at present, this habitat is expected to be sufficient to avoid adverse effects from crowding. However, this considers only the variable of depth but other variables likely affect where suckers occur; for example, 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 (Banish et al. 2009 p. 160). SNS, especially, show a preference for Ball Bay, whereas LRS 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. We presume this distribution is due to selection of habitats beneficial to the LRS and the SNS for additional reasons, such as abundant food, fewer predators, and better water quality.

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 (Bottcher and Burdick 2010 p. 17, Burdick and Vanderkooi 2010 pp. 10, 11, 13). 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 pp. 13–14). In some lakes, ice cover can reduce atmospheric exchange of oxygen and create stressful conditions for fish. However, the limit water quality data available from winter months suggests that this is not a major issue in Upper Klamath Lake, though occasional low DO levels have been observed (USBR 2012 pp. 6–31, 6–32, 6–33).

In addition to the area of habitat within preferred depth ranges, another concern for adult suckers is access to water quality refugia during episodes of poor water quality that are common in Upper Klamath Lake from mid-July through September (Banish et al. 2009 p. 159). The primary location that suckers use for refuge from poor water quality is Pelican Bay. The depth at the entrance to Pelican Bay is relatively shallow, and it could limit access at low lake elevations.

Navigating through shallow water to enter Pelican Bay could also expose suckers to increased avian predation. American white pelicans are depth-limited predators that can prey on adult suckers up to 730 mm in length (Evans et al. 2016a p. 1262). In general, white pelicans are known to forage in shallow waters with majority of foraging occurring in the top 3.3 to 6.6 ft (1 to 2 m) of the water surface (Anderson 1991 p. 167, McMahon and Evans 1992a p. 105, Findholt and Anderson 1995a p. 65, 1995b p. 56). Pelican foraging does occur in deeper water, but is likely a result of prey species coming to the water surface for their own feeding behaviors (Findholt and Anderson 1995a p. 65). Cooperative foraging strategies by white pelicans may increase the success rate of capturing fish (Anderson 1991 pp. 167–170, McMahon and Evans 1992a p. 80, 1992b p. 105); however, individual white pelicans are also quite capable of successfully capturing fish (Anderson 1991 p. 170, McMahon and Evans 1992a p. 80). Fish, as prey species, are more vulnerable to predation by white pelicans in shallow waters (Findholt and Anderson 1995a p. 65, Scoppettone et al. 2014 p. 65), and water depths of over 3.3 ft (1 m) were recommended by Scoppettone et al. (2014 p. 65) as a means to reduce pelican foraging success on catostomids.

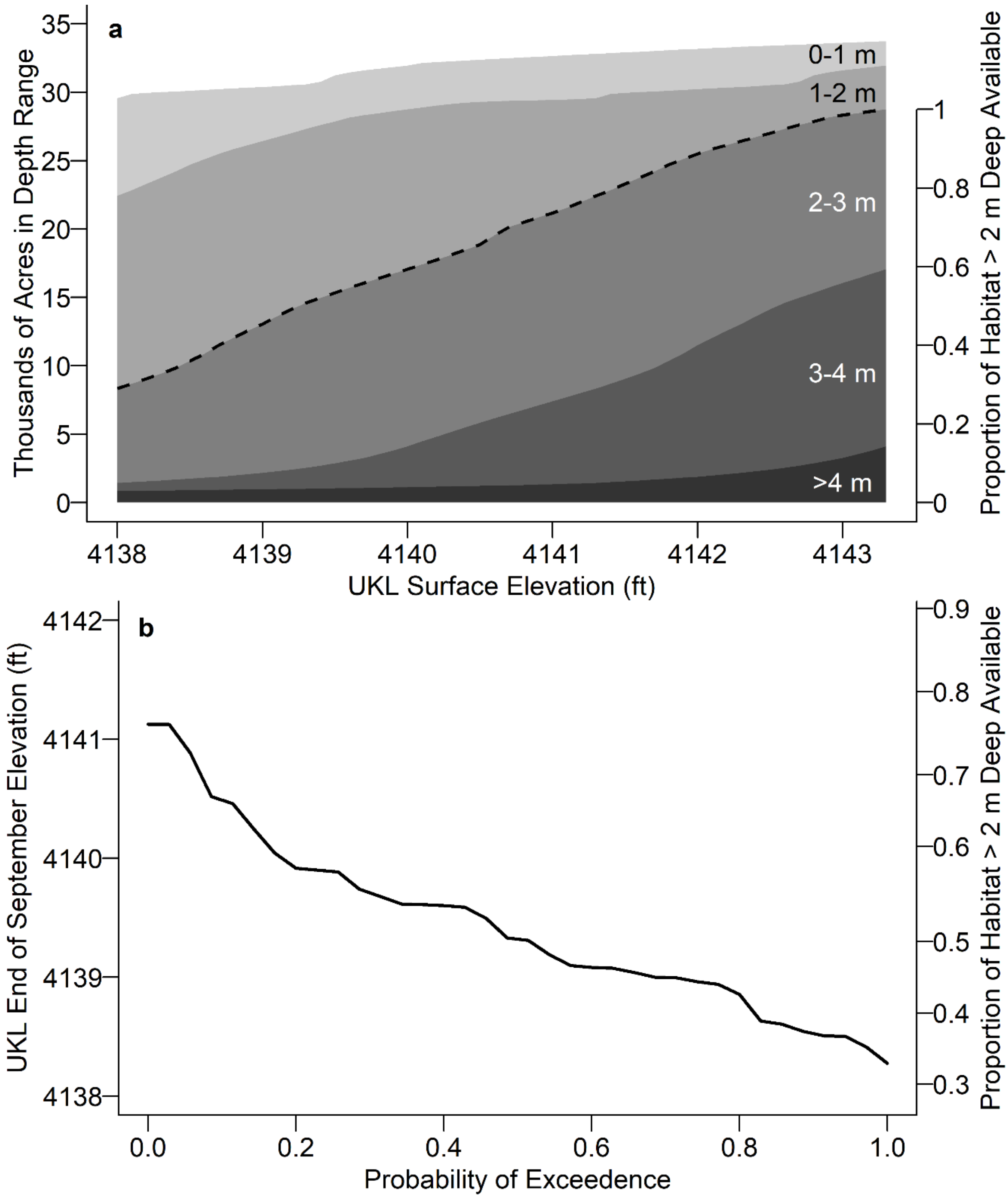


Figure 7-5. a) Availability of habitat of various depths in UKL north of latitude 24°24’47” N—including all of Ball Bay, Shoalwater Bay, and the Williamson River delta—at varying surface elevations based on UKL bathymetry (Shelly et al. 2019). LRS and SNS tend to avoid depths less than 2 m, except when seeking refuge from poor water quality conditions. Shaded areas representing the area in depth categories are stacked, and the dashed line represents the available area (or proportion) of habitat deeper than 2 m relative to availability at full pool. b) The expected frequency of lake elevations and the associated proportion of habitat deeper than 2 m that is available under the proposed action based on the model POR.

New, high-quality bathymetric data are available for the area surrounding Pelican Bay, indicating that the bottom elevation is 4,134.5 ft (1,260.2 m; Shelly et al. 2019). The lowest UKL surface elevation in the model POR in July through September was 4,138.26 ft (1,261.36 m), which would provide a depth of approximately 3.8 ft (1.2 m) at the entrance of Pelican Bay (Table 7-1). This is deeper than 3.3 ft (1 m), so it should prevent the most severe impacts due to pelican predation (Scoppettone et al. 2014 p. 65). However, depths at the entrance to Pelican Bay are expected to be between 4 and 6 ft (1.2 and 1.8 m) during August and September in all but the wettest years, which could increase predation exposure as it is shallower than the habitats they typically select (6.6 ft to 9.8 ft [2 m to 3 m]; Banish et al. 2009; Figure 7-5).

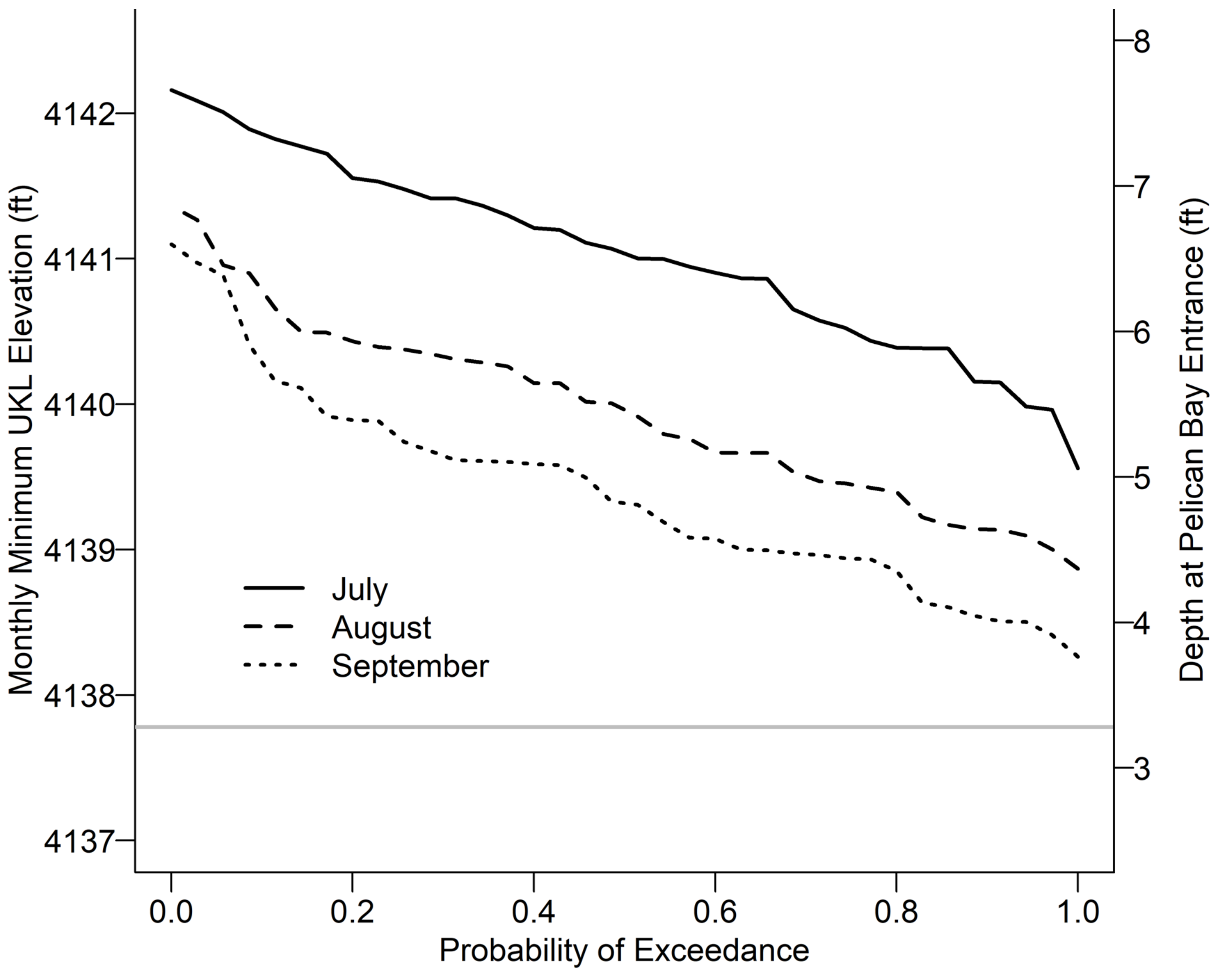


Figure 7-6. Probability of exceedance of monthly minimum UKL surface elevation in July (solid line), August (long dashes), and September (short dashes) for the model POR and the associated depth at the entrance to water quality refuge contained in Pelican Bay. Suckers are expected to avoid depths shallower than 1 m (3.3 ft; gray line).

Table 7-1. Water depths at the entrance to Pelican Bay at various UKL elevations. The minimum bottom elevation at the entrance to the bay is approximately 4134.5 ft (1,260.2 m; Shelly et al. 2019).

Lake Surface Elevation (ft)	Depth of Entrance to Pelican Bay (ft)
4,143.0 (1,262.8 m)	8.5 (2.6 m)
4,142.5 (1,262.6 m)	8.0 (2.4 m)
4,142.0 (1,262.5 m)	7.5 (2.3 m)
4,141.5 (1,262.3 m)	7.0 (2.1 m)
4,141.0 (1,262.2 m)	6.5 (2.0 m)
4,140.5 (1,262.0 m)	6.0 (1.8 m)
4,140.0 (1,261.9 m)	5.5 (1.7 m)
4,139.5 (1,261.7 m)	5.0 (1.5 m)
4,139.0 (1,261.6 m)	4.5 (1.4 m)
4,138.5 (1,261.4 m)	4.0 (1.2 m)
4,138.0 (1,261.3 m)	3.5 (1.1 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. 2000a pp. 16–19, 24–29; see Section 6.5.4). 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.

Although Pelican Bay is the primary water quality refuge, suckers do use other areas, such as the Williamson River and the area along Fish Banks, in smaller numbers. The depths along Fish Banks are similar to those at the entrance to Pelican Bay, so the effects of lake elevation on access to these areas would be similar to those analyzed for Pelican Bay. The mouth of the Williamson River is somewhat deeper, and the proposed action is not expected to limit access.

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. Although the availability of preferred habitats is significantly reduced at low lake elevations, estimates of adult LRS and SNS survival rates in UKL have been high and stable across a range of lake elevations. This suggests that any effects of lake elevation on adult survival within the range expected under the proposed action should be insignificant because they would not be likely to result in a measurable difference in survival. Adverse effects to these age classes beyond those analyzed here may occur if UKL levels fall below the minimum elevation in the model POR under the proposed action: 4,138.26 ft (1,261.36 m).

7.3.1.6 *Effects to UKL Water Quality*

UKL has experienced extremely poor water quality events in the past that have resulted in massive fish die-offs, including thousands of LRS and SNS, as well as pronounced redistribution of fish (Buettner and Scoppettone 1990, Perkins et al. 2000a, Banish et al. 2007, 2009). In UKL, water quality poses the greatest threat to fish from July to mid-October, but especially late July and August (Wood et al. 1996, 2006, Kann 1997, Perkins et al. 2000a, Loftus 2001, Welch and Burke 2001, Morace 2007).

A recurring question related to Reclamation's management of UKL is: how do lake levels affect water quality? A number of possible mechanisms relating lake depth to water quality have been proposed, including hypotheses that suggest that either high or low elevations could increase the probability of poor water quality (Wood et al. 1996, Reiser et al. 2001, Horn and Lieberman 2005, Morace 2007, Jassby and Kann 2010). Most empirical analyses of water quality data from UKL indicate no clear and statistically significant connection between UKL levels and water quality over the range at which the lake is usually managed (4,138 to 4,143.3 ft [1,261 to 1,263 m]; Wood et al. 1996, Morace 2007). However, Jassby and Kann (2010 pp. 41, 45) documented a statistically significant association between chlorophyll-*a* levels in UKL and water elevations for the months of May and June, though the authors note the analyses are exploratory and that this particular result was driven by a few influential data points.

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. 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). These analyses do not preclude the possibility that lake elevations have some influence on water quality; however, they suggest that any effect, if present, is not strong enough to be clearly discernable among the other factors, such as wind and temperature (Kann and Welch 2005), that influence water quality.

Additional analyses were conducted to support the Klamath Tribes water right claim on Upper Klamath Lake as part of the state of Oregon water rights adjudication (Hendrix 2010, Kann 2010, Reiser 2010, Walker 2010). These analyses are available only as court testimony and therefore do not contain the level of detailed documentation of methods and findings typical of peer-reviewed publications or other science produced with similar standards. After evaluating the testimony, the USFWS has determined that the level of detail and methodological concerns prevent its consideration as the best available information. Based on our review of the science, our current understanding of relationships between lake levels and water quality is insufficient to know whether increased or decreased water levels at key times of the year would improve or worsen water quality concerns.

Water quality analyses to date have focused on twice monthly sampling starting in the early 1990s (e.g., Wood et al. 1996, Morace 2007, Jassby and Kann 2010). These data are valuable for evaluating general seasonal patterns and inter-annual differences, particularly for parameters such as nutrient concentrations. However, the water quality variables that are most likely to directly impact suckers, such as pH and DO, can vary widely at the hourly and daily scales, making it more challenging to discern their dynamics from infrequent samples. High frequency DO and pH data are now available with over 15 years of data, and these data may help to place a finer point on any relationship between water quality and lake elevations. However, rigorous analyses needed to evaluate this relationship have not been completed. Therefore, at present, 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]), which is a critical point because poor water quality is suspected to be a significant contributing factor to the lack of LRS and SNS recruitment in UKL.

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 that are unknown and require further study. For example, storage of winter inflows increases residence time, which could increase nutrient retention rates. Conversely, diversion of water through the irrigation season exports nutrients, especially phosphorus and nitrogen contained within AFA colonies, out of the lake (Kirk et al. 2010).

7.3.1.7 *Entrainment Losses of LRS and SNS from UKL*

The proposed action is likely to adversely affect all life stages (other than embryos) through entrainment at the A Canal and Link River Dam. The numbers of suckers at each life stage entrained by the Project are likely to vary annually depending on multiple factors including the volume and timing of flow through the A Canal and Link River Dam, the number of adults in the spawning populations, annual larval production, water quality, wind speed and direction, and other factors. For example, larval densities in UKL can vary by several orders of magnitude across years (Simon et al. 2014), and this variability is likely to have an 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. (2000b, 2000a). Because entrainment estimates require extrapolations from short sampling times to longer periods and from small samples to larger samples, they include substantial uncertainty.

Larval suckers have limited swimming ability and are surface oriented, making them vulnerable to down-lake transport by currents. Vulnerability of larval suckers to entrainment at Klamath Project water management structures in UKL likely depends on lake currents that are a function of wind patterns, especially the 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. 2014). A study that evaluated potential entrainment by modeling passive movement of particles from sucker spawning grounds suggested under some conditions large proportions of the sucker larvae could be transported out of UKL (Wood et al. 2014 pp. 40–41). However, a different conclusion was reached in a study examining larval sucker catches in UKL and Lake Ewauna (Simon et al. 2014 p. 70), suggesting that larvae may not behave as passive particles. Although extrapolating larval samples to obtain estimates of lake-wide larval population size and the proportion of larvae entrained at Link River Dam and the A Canal involves substantial uncertainty, the best available data suggest that entrainment affects a relatively small proportion of sucker larvae (Simon et al. 2014 p. 70).

Sucker entrainment losses at Link River Dam and A Canal resulting from the proposed action can be estimated using the limited available information and calculating from modeled output. Specifically, we derived flows through Link River Dam and the A Canal from the model POR, used estimates of entrained sucker densities by life history stage (Gutermuth et al. 2000b, 2000a), and applied assumptions to account for changes since the Gutermuth et al. (2000a, 2000b) research efforts (e.g., construction of A Canal fish screen and bypass, reduced sucker populations in UKL etc.).

Due to the limited information available on sucker entrainment, a number of assumptions were required to obtain a rough quantitative estimate of entrainment at the A Canal and Link River Dam.

1. Based on estimated changes in LRS and SNS population sizes (Hewitt et al. 2018) and assuming no recruitment, the total number of adult LRS and SNS in UKL has likely declined about 80 percent since 1998. This is the same estimate used in the 2013 BiOp, but new information indicates that populations were likely slightly higher at that time and have since declined to around the 80 percent level (Hewitt et al. 2018). Therefore, we assume numbers of larvae present and in the lake and entrained at the A Canal has also decreased by 80% because fewer adult females are now present and available to spawn.

2. We assume that due to the reduction in spawning effort and adult populations, the density of suckers of each life stage in water passing through the A Canal and Link River Dam is equal to 80% of the observed densities in Gutermuth et al. (2000a, 2000b), except for juvenile suckers at the A Canal for which we used density estimates based on catches at the A Canal Fish Evaluation Station (FES; Appendix A; USBR 2018b Appendix B).

3. We assume that larvae are vulnerable to entrainment from April 1 to July 14, after which they are considered juveniles; juveniles are vulnerable to entrainment from July 15 to October 31; and adults are vulnerable from April 1 to October 31.

4. Because we do not have sufficient information about within- and among-year variation in entrainment for most life stages, we assume that the density of vulnerable life stages in water passing through the A Canal and Link River Dam are constant within and among years. The exception to this is entrainment of juveniles at the A Canal for which seasonal variation was estimated based on catches at the FES (Appendix A).

5. The A Canal is equipped with a state-of the-art fish screen meeting USFWS criteria, which was recently shown to screen about 80% of larvae at 10 mm and more than 90% of larvae at 16 mm; all fish larger than 20 mm are expected to be diverted (Simon et al. 2014 pp. 72, 101–102). Sucker larvae emerge from the gravel at around 10 mm (Cooperman and Markle 2003 p. 1143); thus, we infer that a minimum of 80% of larvae

that encounter the fish screen are diverted and 20% pass into the A Canal, and we assume that all juveniles and adults are prevented from entering the A Canal. Because the pumped by-pass does not operate until juveniles are expected in the system, the 80% of larvae that are screened from entering the A Canal are expected to be discharged into the Link River through the gravity-operated flume.

6. We assume that suckers passing through the gravity-operated flume and Link River Dam experience a disruption to their normal behaviors, such as feeding and predator avoidance. We also assume that 2% of suckers will be killed 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 (Whitney et al. 1997 pp. 16–17, Muir et al. 2001 p. 142).

7. Fish that are screened from the A Canal are bypassed back to UKL by a pump (typically from mid-July 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 pp. 9–13). Thus, we assume that kill and injury rates would be less than or equal to the 2% that are expected to be injured or killed as they pass through a dam spillway, as described above. The outlet of the pump-bypass flume is about 0.3 mi (0.5 km) from the Link River Dam. If the suckers move at random upon exiting the pump-bypass flume, half would be expected to move "upstream" back into the main body of UKL and half would be expected to be entrained at Link River Dam. Therefore, we assume that 50% of suckers that are bypassed are subsequently entrained at the Link River Dam.

8. Although 100% of juvenile suckers should be screened from entrainment into the A Canal, the pumped bypass could injure or kill some individuals as described above. Adult suckers should not be entrained at the A Canal because they should be excluded by the trash rack, which has 2 in (5 cm) openings; this is confirmed by no observations of adult suckers during FES sampling.

9. As part of the proposed action, some suckers that enter the Project irrigation canals will be salvaged in the fall during canal drawdown. The number of suckers salvaged annually averaged 321 from the canal system and 201 from the A Canal forebay between 2008 and 2017 (USBR 2018b Appendix C p. 31). These efforts help to minimize the effects of entrainment into the A Canal, but the number of suckers salvaged in each year varies widely. Therefore, we conservatively assume that all of the sucker larvae entrained into the A Canal are killed by adverse water quality, passing through pumps and being discharged onto agricultural fields, or desiccation at the end of the irrigation season when irrigation canals are drained.

Applying seasonal occurrences of sucker life history stages, based on Gutermuth et al. (2000a, 2000b), to the volume of water that Reclamation anticipates delivering through the Link River and A Canal using the assumptions described above, the proposed action yields estimates of average annual entrainment of approximately 1.7 million larval suckers, 14,933 juvenile suckers, and 44 adult suckers at either Link River Dam or A Canal fish screen and bypasses (Table 7-2).

We assume that all entrained fish experience disruption of normal behaviors, such as feeding and sheltering, with a small proportion injured or killed, as described in the assumptions above. Entrainment has adverse impacts to larvae, juveniles, and adults of both species of suckers. Sucker entrainment at Link River Dam and A Canal will continue under the proposed action. Under the proposed action, continued operation of the A Canal fish screen, fall canal salvage efforts, captive sucker rearing, and support for studies and recovery actions to reduce juvenile mortality in UKL collectively minimize the impacts of entrainment at project facilities.

Table 7-2. Adverse effects of entrainment at the A Canal and Link River under the proposed action averaged over the model POR. See assumptions above. Note killed individuals are included in the totals for disrupted behavior.

	Disrupt Behavior	Kill
Adults at A Canal	0	0
Adults at Link River	44	2
Juveniles at A Canal	8,060	161
Juveniles at Link River	6,873	137
Larvae at A Canal	459,912	99,341
Larvae at Link River	1,255,232	25,105

7.3.1.8 *Effects of Deliveries to Lower Klamath National Wildlife Refuge*

The proposed action allows for the possible delivery of Project Supply to LKNWR, which may result in changes to UKL elevations relative to the model POR. Although the proposed action specifically states that such deliveries would not result in an increase in the volume of water delivered from UKL, the timing of deliveries is likely to change due to differences in the seasonal water rights and demand between irrigation and LKNWR. Generally, in the model POR, water delivery was assumed to be spread out across the irrigation season with a peak in July, whereas LKNWR deliveries would occur in August through November. Therefore, delivery of Project Supply to LKNWR would be expected to delay the delivery of a portion of Project Supply, resulting in a temporary increase in UKL elevations in summer that would gradually diminish as water is delivered to LKNWR. This change would result in slight, temporary increases to the available habitat for juveniles and adults in UKL relative to the analysis above and would thus be considered within the scope of this effects analysis.

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

Small numbers of the LRS and the SNS reside in the Keno Reservoir and in the downstream hydropower reservoirs operated by PacifiCorp with SNS outnumbering LRS in these locations (Desjardins and Markle 2000, PacifiCorp 2000, Korson et al. 2008, Kyger and Wilkens 2011a). Poor habitat conditions, nonnative fishes, and a lack of successful reproduction are thought to be responsible for the small numbers of LRS and SNS present in these reservoirs (Desjardins and Markle 2000, Piaskowski 2003).

The potential effects of the proposed action on the LRS and the SNS in the Link River and Keno Reservoir are entrainment, impaired water quality, and alterations to habitat. Entrainment in Project facilities is a 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. 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 where they could be vulnerable to entrainment (Phillips et al. 2011), and small numbers of suckers have been captured in the Lost River Diversion Channel (Foster and Bennetts 2006). 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.

Water quality may also be reduced in Keno Reservoir by nutrient-rich agricultural return flows entering the reservoir at the Straits Drain and from the Lost River Diversion Channel in winter/spring (Kirk et al. 2010). However, overall, the diversion of water from UKL through the Project results in a net reduction of nutrients entering Keno Reservoir from UKL (Kirk et al. 2010). Therefore, the effects of Project operations on water quality in Keno Reservoir above and beyond the conditions described in the environmental baseline are expected to be minimal.

Habitat effects to LRS and SNS may include alterations to spawning habitats, fish passage, and rearing habitats. 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, there is an anecdotal report of sucker spawning activity 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 pp. 9–10). 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.

Larval and age-0 juvenile suckers enter Keno Reservoir after entrainment or dispersal from UKL. More age-0 juvenile suckers were captured in trap nets fished close to the shoreline near emergent vegetation than in open water areas in Lake Ewauna (Phillips et al. 2011). Furthermore, sampling in a reconnected wetland bordered by North and Ady canals captured more age-0 juvenile suckers in transition zones near emergent vegetation than in open water or in vegetation (Phillips et al. 2011). These data suggest that wetland habitat availability may be important for juvenile suckers in Keno Reservoir. The proposed Project operations maintain a surface elevation in the Keno Reservoir of 4,086.5 ft (1,245.6 m), except for the possibility of several days during the spring when the surface elevation may be 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 (Middleton 1999 pp. 99–133); however, they do provide for consistent inundation of available wetland habitat and are thought to be similar to those that occurred naturally due to the reef at the present day Keno Dam site that controlled water levels (Weddell 2000).

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, and 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 generally keeps the reservoirs full, except for daily changes in reservoir elevations for hydroelectric generation.

In sum, the proposed action could have a variety of adverse effects to the LRS and the SNS in Keno Reservoir, including entrainment into Project facilities and adverse water quality. Below Keno Dam, effects are likely limited to reduced water quality. The effects of reduced water quality to the LRS and the SNS are unknown and are not likely to be substantial at a population level because of the low numbers of suckers present in the reservoirs.

7.3.3 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 LRS populations with successful reproduction and contains the largest LRS population remaining within its range. The UKL recovery unit contains one of only three SNS populations known to successfully reproduce.

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 larval and age-0 juvenile habitat between July and October; (2) decreased availability of habitat with adult suckers' preferred depths at the lowest water levels; (3) decreased access to shoreline spawning habitat in years with the lowest water levels; and (4) substantial entrainment of larvae and age-0 juveniles at the A Canal and Link River Dam.

As described above, the proposed action is also likely to have beneficial effects to the LRS and SNS populations in the UKL recovery unit. These 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, (2) lake level variations that could help maintain marsh vegetation that requires air exposure for seedling growth, and (3) increased juvenile survival through assisted rearing (described 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 embryonic, larval, juvenile, and adult suckers, as well as entrainment of larvae, juveniles, and adults. 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 that affect habitat for sucker spawning and early life-stages are unlikely to occur during the 5-year term of the proposed Project operations because of the low frequency of problematic lake elevations that are found in modeling of the POR.

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 possible (Hewitt et al. 2018 pp. 12, 17, 21, 25), then any loss of young suckers by entrainment or other actions resulting from Project operations would reduce recruitment. Given the lack of substantial recruitment into the adult populations of the LRS and the SNS at UKL since the late 1990s (Hewitt et al. 2018 p. 24), recruitment at UKL during the near term (i.e., 10 years) is essential to the survival and the recovery of the LRS and the SNS because of the important role that UKL plays in the conservation of these species (Hewitt et al. 2018 p. 24, Rasmussen and Childress 2018 pp. 4–8). We anticipate that adverse effects to the declining sucker populations in UKL as a result of Project operations will be minimized through the proposed assisted rearing program and the recovery team participation in beneficial actions, both of which are discussed below.

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

The Lost River Subbasin 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 2013a). 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 are 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 essentially 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.

7.4.1 Effects to LRS and SNS in Clear Lake

Clear Lake has populations of both LRS and SNS. The SNS population is likely of similar size to the one in UKL based on similar annual catch rates, while the LRS population is much smaller than that in UKL (Hewitt and Hayes 2013 pp. 5, 12). 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 30 of each year (USBR 2018a). 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.

Under the proposed action, Reclamation plans to estimate irrigation water supplies and ensure lake levels stay above the minimum using a method similar to the process used for past Project operations. 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 2018a). 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 2018a). For example, deliveries were curtailed in 2013 and eliminated in 2014 and 2015 due to low surface elevations and projected inflow (T. Tyler, USBR personal communication, December 18, 2018).

Proposed operations were evaluated for potential effects to adult sucker spawning and migration, habitat for larvae and age-0 juveniles, habitat of older juveniles and adults, water quality, and the likelihood for entrainment and stranding.

7.4.1.1 *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 (Hewitt and Hayes 2013 pp. 4–5; D. Hewitt, Personal Communication). 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 sucker access to the creek appears to depend on a combination of Willow Creek discharge and a lake elevation of at least 4,524 ft (1,378.9 m) (Barry et al. 2009 pp. 5–6, 8, Hewitt and Hayes 2013; D. Hewitt, Personal Communication). The spawning season varies among years; it can begin as early as the end of January and extend through May (Hewitt and Hayes 2013 p. 15). Thus, in years when lake levels are low prior to the spawning season and/or there are not substantial inflows, spawning migrations contain few individuals.

Low lake levels early in the season followed by high inflows, as occurred in 2011, can provide access to Willow Creek for a lake spawning effort due to rapid increases in lake levels (USBR 2018a). Under most hydrologic conditions observed between 1986 and 2018, the period for which inflow estimates are available, the lowest proposed end-of-year target (4520.6 ft) would result in lake elevations below 4,524 ft (1,378.9 m) at the end of January (89% of years), February (84% of years), and March (60% of years), significantly limiting access to spawning habitat in Willow Creek. However, because spawning access is also limited by streamflow and high streamflows would also result in more rapid increases in lake elevation, lake elevations in the wettest years would rise sufficiently to provide access. In dry years, streamflows would preclude substantial spawning regardless of lake elevation. Concern arises in moderately wet years, in which the impact of lake management on spawning access is uncertain.

In water years 1911 through 2018, lake elevation was less than 4,524 ft (1,378.9 m) at the end of September in 27% of years (Table 8-3). However, between 1999 and 2018, lake elevation at the end of September was below 4,524 ft (1,378.9 m) in 60% of years, indicating that these conditions have been more common in the recent past. Similarly, end of September lake elevation was less than or equal to 4,520.6 ft (1,377.9 m) in only 8% of years since 1911 (Table 8-3) but in 20% of years since 1999. These conditions are likely due to drier hydrologic conditions in recent years, though Project operations may have also contributed. Regardless, the lower lake elevations in recent years make understanding the impacts of the Project critically important for ensuring adequate access to spawning habitat. Based on the period of record in Table 7-3 (1911-2018), the probability of lake levels below desired conditions of 4,524 ft (1,378.9 m) is 17% at the end of February, 11% at the end of March, and 10% at the end of April. Similar to the patterns described above, these conditions are more frequent in the 1999-2018 period, with 45% of years below 4,524 ft (1,378.9 m) at the end of February and 25% of years at the end of March and April. Based on the best available information and the stated considerations, we expect that operations will allow for successful spawning in most years because lake elevations are likely to stay at levels that allow for refill that will then accommodate spawning in moderately wet years. Spawning in drier years will likely be restricted by streamflow, so lake elevations may not be as important. However, the USFWS believes that it is very important to refine our understanding of Project impacts to spawning access and that a synthesis of hydrologic and sucker spawning data from Clear Lake could be completed within 2 years.

7.4.1.2 *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 they do not use emergent wetland vegetation because it does not exist in Clear Lake. Because Clear Lake is large and shallow, it has little substrate diversity compared to UKL, so 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. Because successful spawning only occurs at higher lake elevations and stream inflows, as described above, years with substantial larval production are likely to coincide when lake elevations that are relatively high due to large inflows, and thus, young-of-the-year habitat is not likely to be limiting when larvae and age-0 juveniles are present. Therefore, proposed Project operations effects on larval and age-0 juvenile habitat are insignificant.

7.4.1.3 *Effects to Habitat of Older Juveniles and Adults*

The limited available data suggest that older juvenile (including sub-adults) and adult suckers in Clear Lake use habitats that are shallower than the preferred habitats in UKL (Scoppettone et al. 1995 pp. 34–35). However, this conclusion is based on catch data, and variation in capture efficiency with depth could drive the observed pattern. 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 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 full POR, there is a 31 percent probability that lake levels will reach 4,523 ft (1,379 m) or less during the year; however, these conditions occurred in 65 percent of years since 1999. Thus, conditions that are likely to cause adult suckers to avoid the east lobe of the lake are expected to occur during the term of this BiOp.

At the proposed 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 8 percent. However, because 4 of the 10 years in the POR when this happened were in the past two decades (2004, 2010, 2014, and 2015), the current cycle of drier conditions is reasonably likely to continue and the incidence of low lake levels is likely to be greater during the term of this BiOp than the full POR suggests.

During droughts, the proposed action at Clear Lake could impact older juvenile and adult suckers by reducing habitat availability, particularly lake surface area and depth. Higher catch rates of adult SNS and LRS in Clear Lake at low lake elevations, suggests that suckers do become concentrated as the available habitat area decreases (Hewitt and Hayes 2013 p. 4). The effects of crowding on parasite levels and growth rates are not known, but limited data available suggest that low lake levels in 1992 were followed by slight reductions in condition factor and increases in afflictions the following spring that were no longer apparent by summer (USBR 1994 p. 12). Suckers in Clear Lake are also vulnerable to avian predation, which may be exacerbated during low lake elevations, particularly as they congregate in preparation for the spring spawning migration (Evans et al. 2016a pp. 1262, 1265). However, the details of the potential relationship between avian predation and lake elevations is not currently understood nor is the relationship between lake elevations and annual survival rates more broadly. The dynamics of bird colonies at Clear Lake could drive either an increase or a decrease in mortality with increasing lake elevation. For example, low lake elevations could make suckers more vulnerable to avian predation due to shallower depths; however, the bird colonies tend to be smaller at low lake elevations because land predators have access to the available nesting sites (Evans et al. 2016a p. 1261). Therefore, based on the available information, we do not expect that extent of reduced habitat availability under the proposed action will amount to adverse effects to adult or older juvenile suckers.

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 and LRS exhibit broader size distributions than those in UKL and include multiple, distinct size classes, especially for SNS, indicating at least intermittent recruitment (Hewitt and Hayes 2013; D. Hewitt, Personal Communication). Therefore, based on the best available information, it does not appear that the lake elevations under the proposed action will result in adverse effects to adult suckers due to changes in habitat availability.

Table 7-3. Clear Lake surface elevation probability of exceedance in ft for the period of 1911 through 2018 (USBR 2018a Table 6-4).

Prob. Exceed.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4,518.94	4,518.95	4,519.27	4,519.89	4,521.21	4,522.05	4,522.33	4,521.66	4,520.73	4,519.98	4,519.47	4,518.69
90%	4,521.26	4,521.35	4,521.77	4,521.85	4,522.56	4,523.87	4,524.18	4,523.99	4,523.31	4,522.32	4,521.30	4,521.14
85%	4,521.83	4,522.00	4,522.38	4,523.22	4,523.61	4,525.70	4,525.64	4,525.29	4,524.40	4,523.08	4,521.91	4,521.79
80%	4,522.53	4,522.52	4,523.23	4,523.86	4,524.74	4,526.22	4,526.47	4,526.07	4,524.94	4,523.83	4,522.75	4,522.38
75%	4,523.80	4,523.80	4,524.40	4,524.74	4,525.64	4,527.00	4,527.52	4,527.35	4,526.65	4,525.43	4,524.35	4,523.68
70%	4,524.33	4,524.51	4,525.24	4,525.91	4,526.38	4,527.39	4,528.59	4,528.17	4,527.35	4,526.20	4,525.10	4,524.39
65%	4,525.56	4,525.84	4,526.24	4,526.69	4,527.12	4,528.47	4,529.02	4,529.08	4,528.54	4,527.32	4,526.58	4,525.78
60%	4,526.29	4,526.22	4,526.69	4,527.15	4,528.01	4,529.52	4,530.05	4,529.84	4,529.15	4,528.00	4,527.16	4,526.77
55%	4,526.97	4,527.04	4,527.77	4,528.25	4,529.10	4,530.57	4,531.25	4,530.67	4,530.01	4,529.03	4,527.94	4,527.23
50%	4,527.97	4,527.94	4,528.40	4,528.88	4,530.01	4,530.88	4,531.83	4,531.63	4,531.15	4,530.15	4,529.08	4,528.23
45%	4,529.22	4,529.18	4,529.63	4,529.94	4,530.77	4,531.62	4,532.51	4,532.40	4,531.69	4,530.99	4,530.17	4,529.50
40%	4,529.76	4,529.75	4,530.19	4,530.96	4,531.75	4,532.80	4,533.72	4,533.37	4,532.49	4,531.48	4,530.65	4,530.01
35%	4,530.49	4,530.63	4,530.80	4,531.37	4,532.46	4,533.63	4,534.23	4,533.74	4,533.23	4,532.34	4,531.46	4,530.80
30%	4,531.22	4,531.19	4,531.51	4,532.08	4,533.45	4,534.06	4,534.85	4,534.59	4,533.90	4,532.92	4,531.95	4,531.37
25%	4,531.83	4,531.71	4,532.05	4,533.32	4,533.87	4,535.11	4,535.54	4,535.13	4,534.55	4,533.53	4,532.76	4,531.87
20%	4,533.14	4,533.13	4,533.25	4,533.98	4,534.59	4,535.78	4,536.76	4,536.36	4,535.68	4,534.74	4,533.99	4,533.41
15%	4,533.48	4,533.57	4,533.78	4,534.45	4,535.62	4,536.90	4,537.79	4,537.52	4,536.62	4,535.65	4,534.63	4,533.77
10%	4,534.13	4,534.00	4,534.20	4,535.10	4,536.21	4,537.95	4,538.35	4,537.85	4,537.09	4,536.02	4,535.09	4,534.39
5%	4,534.99	4,534.92	4,535.55	4,536.12	4,537.24	4,538.80	4,539.22	4,539.04	4,538.47	4,537.47	4,536.20	4,535.53

7.4.1.4 *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 (USBR 1994, 2001a, 2007, 2009). 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 preliminary data suggested that fish exhibited poorer condition the following spring, condition factors had more than rebounded by summer, suggesting that any effects were ephemeral (USBR 1994 p. 12). It is uncertain what caused the poor condition, but it could be related to reduced water quality, crowding and competition for food, parasites, or a combination of these were responsible. Based on this, very low lake levels in Clear Lake could pose a potential risk to listed suckers from adverse water quality. However, under reservoir management consistent with the proposed action, the water quality 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, 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 due to water quality.

7.4.1.5 *Effects of Entrainment and Stranding Losses of LRS and SNS at Clear Lake*

The outlet at Clear Lake Dam is screened against fish entrainment. The screen was designed for a fish approach velocity not to exceed 0.75 feet per second (0.23 m/s), and with a mesh size no larger than 1/4 inch (6 mm). The required total area of the fish screens was determined based on a flow of 200 cfs and the above screening criteria. With full screen submergence and a discharge of 200 cfs, the screen approach velocity is approximately 0.53 ft/s (0.16 m/s). However, Reclamation estimated that about 270,000 larval suckers and about 3,700 juvenile suckers passed through or around the fish screen into the Lost River at Clear Lake Dam in 2013 (Sutphin and Tyler 2016). There are no available estimates of larval production in Clear Lake, making it difficult to infer population level impacts of larval entrainment for suckers in Clear Lake. Entrainment is likely variable between years and dependent on annual larval and juvenile production, timing of larval outmigration from Willow Creek, juvenile sucker distribution within the East and West lobes, and the timing and magnitude of irrigation releases.

Because the 2013 study is the best available information we have on larval densities and entrainment from Clear Lake, we used it as the basis for entrainment estimates for the period with robust dam release data (1986-2018). We excluded the years with flood-control releases (1998 and 1999) and 2000 due to drawdown prior to reconstruction of the dam in 2001. Flood-control releases are not within Reclamation's discretion, and drawdown for construction similar to what happened in 2000 is not expected under the proposed action. Based on the Gutermuth et al. (2000a, 2000b) studies, we assumed that entrainment was proportional to the volume of water released from the dam. Larval sucker entrainment was concentrated in the spring with the bulk of the catch coming between the last week of April and mid-May, but some larval entrainment was observed into June (Sutphin and Tyler 2016 pp. 10–12). The timing of larval drift is likely to vary among years. Based on the timing of adult migration relative to the run in 2013 (Hewitt and Hayes 2013; D. Hewitt, Personal Communication), we infer that the larval entrainment period most likely falls between April 1 and June 30 in all years. Because we do not have information on the interannual variation in larval abundance, we assumed that 2013 was representative of larval densities in Clear Lake. Thus, we multiplied average larval densities between April 22 and June 30, 2013 (22.3027 larvae/AF), by the volume of water released from Clear Lake in April-June for each water year between 1986 and 2018 (excluding the water years mentioned above) to estimate larval entrainment. Estimated larval entrainment ranged from 0 in years with no deliveries from Clear Lake to around 574,000 in 2001, when higher than normal deliveries were made from Clear Lake due to the shutdown of deliveries from UKL. The mean estimated larval entrainment over that period was 241,000.

Juvenile sucker entrainment was estimated in a similar manner except there was no apparent seasonal pattern in juvenile sucker entrainment during the 2013 study, so we assumed that juvenile entrainment is constant across the year. Thus, the average density of juvenile suckers from the 2013 study (0.1867 juveniles/AF) was multiplied by the total releases for the water year. The mean estimate was 5,050 and estimates ranged from 0 to 12,200. No adults are expected to be entrained due to the fish screen at Clear Lake Dam.

Suckers entrained at Clear Lake Dam are lost from the spawning population because there is no upstream passage at Clear Lake Dam or Gerber Reservoir Dam nor is there substantial spawning habitat further downstream in the Lost River system. Therefore these individuals would most likely not be able to complete their life-cycle through reproduction, and entrainment is an adverse effect. Additionally, we expect that up to 2% of the entrained individuals could be killed as they pass through the dam, as described above for Link River Dam (Whitney et al. 1997 pp. 16–17, Muir et al. 2001 p. 142).

Total larval and juvenile production in Clear Lake are not known. If the numbers of entrained individuals are a substantial proportion of the number available in any year, then there is likely an adverse impact to sucker populations at Clear Lake resulting from entrainment losses that result from the proposed action. Still, the proposed action for Clear Lake is consistent with the historical operations at the reservoir, therefore the potential entrainment impacts are not anticipated to be greater than those in the recent past, which have allowed for recruitment of multiple cohorts.

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); 48 juvenile suckers were captured in the forebay of the dam and moved to the west lobe of Clear Lake and two adult suckers were found dead (USBR, Unpublished Data). The pool nearest the dam is the only known area at Clear Lake that poses a stranding risk, and given the low numbers of suckers observed 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.

7.4.1.6 *Summary of Effects to LRS and SNS in Clear Lake*

Based on the analysis presented above, the effects of the proposed action to suckers in Clear Lake likely include: (1) entrainment of larval and juvenile suckers at Clear Lake Dam and (2) stranding of juveniles and adults at low lake levels. The action may also have some effects that reduce habitat availability, which are not anticipated to affect the population size. The best available information indicates that the proposed action is not likely to affect spawning access in dry conditions because low streamflow inhibits spawning. It is also unlikely to affect spawning under the wettest conditions because lake levels will rise rapidly allowing spawning access even if lake elevations are low in the fall, but uncertainty remains about Project impacts during moderately wet years when lake elevations are low.

7.4.2 Effects to the SNS in Gerber Reservoir

Only SNS, not LRS, occur in Gerber Reservoir. The proposed action at Gerber Reservoir, which is unchanged from past operations identified in previous Project consultations, is designed to ensure that the surface elevation is at or above 4,798.1 ft (1,462.5 m) on September 30 (USBR 2018a pp. 4–37). Table 7-4 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. As described in the proposed action, 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. 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.

Table 7-4. Probability of exceedance for end of month surface elevations at Gerber Reservoir 1925-2018 in feet above mean sea level, Reclamation datum (USBR 2018a Table 6-4).

Prob. Exceed.	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4,797.95	4,797.94	4,800.23	4,800.12	4,804.94	4,809.13	4,809.03	4,807.95	4,804.31	4,801.93	4,799.68	4,798.15
90%	4,802.24	4,804.01	4,805.49	4,805.65	4,807.73	4,812.34	4,814.50	4,815.20	4,811.86	4,807.54	4,805.14	4,802.23
85%	4,804.18	4,804.94	4,807.04	4,808.27	4,809.13	4,814.90	4,818.65	4,817.53	4,815.29	4,811.36	4,807.19	4,803.99
80%	4,805.96	4,806.81	4,808.91	4,810.97	4,812.46	4,817.22	4,819.87	4,819.03	4,816.28	4,812.36	4,809.01	4,805.84
75%	4,806.99	4,807.46	4,809.26	4,812.22	4,814.47	4,818.67	4,821.41	4,820.16	4,817.04	4,813.49	4,809.86	4,806.96
70%	4,808.29	4,809.54	4,811.41	4,813.54	4,815.76	4,820.04	4,822.17	4,820.50	4,817.79	4,814.80	4,812.05	4,808.49
65%	4,810.51	4,810.89	4,812.86	4,814.64	4,816.83	4,821.32	4,823.27	4,821.92	4,819.11	4,815.44	4,812.95	4,810.68
60%	4,812.10	4,811.96	4,814.36	4,816.33	4,817.64	4,822.14	4,824.90	4,823.11	4,821.46	4,817.50	4,815.48	4,812.43
55%	4,813.69	4,814.14	4,815.42	4,816.79	4,818.06	4,823.81	4,826.43	4,825.00	4,822.53	4,819.63	4,816.47	4,814.01
50%	4,814.62	4,815.24	4,817.40	4,817.42	4,819.93	4,824.67	4,827.31	4,826.11	4,823.60	4,820.75	4,817.91	4,815.32
45%	4,816.83	4,816.71	4,818.68	4,817.93	4,820.82	4,825.39	4,828.69	4,827.00	4,824.52	4,821.65	4,819.16	4,817.36
40%	4,817.65	4,817.69	4,820.06	4,820.34	4,821.61	4,826.04	4,829.42	4,828.09	4,825.81	4,822.80	4,820.53	4,818.68
35%	4,819.52	4,819.78	4,820.63	4,820.75	4,822.96	4,826.77	4,830.18	4,829.80	4,828.05	4,825.29	4,822.12	4,819.91
30%	4,820.54	4,820.56	4,821.48	4,821.12	4,823.41	4,828.30	4,831.66	4,830.79	4,829.47	4,826.43	4,823.31	4,820.77
25%	4,821.02	4,821.46	4,822.45	4,823.13	4,824.75	4,830.64	4,832.23	4,831.98	4,829.72	4,826.78	4,823.58	4,821.24
20%	4,821.90	4,822.43	4,823.04	4,824.08	4,826.00	4,831.66	4,834.07	4,832.97	4,830.41	4,827.26	4,824.51	4,822.48
15%	4,822.75	4,822.91	4,823.86	4,825.59	4,828.50	4,832.58	4,834.93	4,833.58	4,831.01	4,827.99	4,825.13	4,823.41
10%	4,824.12	4,824.24	4,825.19	4,826.59	4,830.84	4,834.46	4,835.50	4,834.51	4,832.21	4,829.35	4,826.81	4,824.43
5%	4,825.57	4,825.76	4,827.54	4,829.68	4,833.20	4,835.69	4,835.81	4,834.86	4,833.16	4,830.79	4,828.06	4,825.78

7.4.2.1 *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) based on the reservoir bathymetry (USBR 2018a pp. 6–27), and the spawning season extends from February through May. 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 2001b). 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 2018a Appendix 6B).

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, and annual production of larvae is not likely to be a limiting factor for SNS in Gerber Reservoir.

7.4.2.2 *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 well understood. However, available information indicates that the Gerber Reservoir SNS population has remained viable, showing regular recruitment under the current management regime (Barry et al. 2007, Leeseberg et al. 2007, USBR 2018a pp. 7–26). 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.

7.4.2.3 *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, 2009, Piaskowski and Buettner 2003). Although periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers, 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 pp. 6–10). 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 would 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 apparent stability of the SNS population in Gerber 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.

7.4.2.4 *Effects of Entrainment Losses of SNS at Gerber Reservoir*

Sampling and salvage efforts in Miller Creek downstream from Gerber Dam have captured several hundred age-0 and older juvenile suckers that were presumably entrained at the dam as result of Project operations (Hamilton et al. 2003). Because the proposed action is consistent with past operations, the scale of adverse effects is expected to be comparable as well. Larval suckers are also likely entrained, but this has not been studied.

The proposed action includes opening Gerber Dam frost valves at the end of the irrigation season, which allows for a flow of approximately 2 cfs (0.06 m^3/sec) in Miller Creek. Downstream accretions from seeps and storm runoff increase the actual instream flow within Miller Creek. This flow may not be sufficient to allow for stream pool connectivity, but it is believed to prevent mortalities among fish stranded in stream pools at the end of the irrigation season (USBR 2018a pp. 7–27).

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 indicates that the Gerber Reservoir SNS population has remained moderately large and has frequent recruitment under the current management regime (Barry et al. 2007, 2009, Leeseberg et al. 2007), 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.

7.4.2.5 *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 are not anticipated to change, adverse effects are unlikely to occur at a level that limits the persistence of SNS in Geber Reservoir.

7.4.3 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 LRS and SNS located in Sump 1A (Hodge and Buettner 2009). 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 p. 6). 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 2009 p. 8), lack of spawning habitat probably prevents them from reproducing. These, populations appear to be maintained by emigration from populations in UKL, Gerber Reservoir, and/or Clear Lake. The proposed action will manage Tule Lake Sump 1A for a surface elevation of 4,034.0 ft (1,229.6 m) throughout the year, providing habitat with areas of water depth greater than 3 ft (1 m) for older juveniles and adults, particularly in the area where adult suckers have typically been observed during the summer months (i.e., the "donut hole"; J. Spolar, Personal Communication, February 5, 2019).

Proposed operations were evaluated for potential effects to adult sucker spawning and migration, habitat for larvae and age-0 juveniles, habitat of older juveniles and adults, water quality, and the likelihood for entrainment. Sucker relocation was also evaluated.

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

In previous BiOps (USFWS 2008, 2013d), a minimum surface elevation of 4,034.6 ft (1,229.8 m) in Sump 1A was thought to provide sucker access to spawning areas below Anderson Rose Dam during the spring migration. Although LRS and SNS adults have been observed migrating into the lower Lost River during the spring spawning season, it appears that successful reproduction is limited by a lack of suitable substrates and flows at the dam (Hodge and Buettner 2009 pp. 5–6, 9). Additionally, during a review of the best available information, USFWS was not able to find information that related Tule Lake elevations with spawning access. The proposed action manages Sump 1A for a surface elevation of at least 4,034.0 ft (1,229.8 m) year-round, which does not reduce connectivity with the Lost River based on the available information. However, the Tule Lake populations do not currently successfully reproduce, and Project operations are unlikely to change that.

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, past Project operations are in-part responsible for variable flows and the loss of spawning substrate. 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 are regulated, and significant habitat restoration efforts are implemented.

7.4.3.2 *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 (Markle and Dunsmoor 2007). The minimum elevation of 4,034.0 ft (1,229.6 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. Therefore, the proposed action at Tule Lake is unlikely to limit larval and age-0 juvenile habitat.

7.4.3.3 *Effects to Habitat for Older Juveniles and Adult LRS and SNS in Tule Lake*

Water depth as cover for older juveniles and adults is limited due to the shallow depth of Tule Lake sump 1A, which is mostly less than 4 ft (1.2 m). One reason for the shallow depths is Tule Lake is the terminus of the Lost River and sediment is transported downstream and collects there. 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 4,034.0 ft (1,229.6 m) appear to provide areas with water depth greater than 3.3 ft (1 m) for older juveniles and adults, particularly in the area where suckers have been observed during movement studies (J. Spolar, Personal Communication, February 5, 2019). As discussed above, sucker vulnerability to American white pelican predation is expected to be increased in water depths of around 3.3 ft (1 m) (Scoppettone et al. 2014 p. 65), and there is continued concern about the possibility of decreasing water depths in the future due to continued sedimentation. 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. Overall, 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.

7.4.3.4 *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 the *Environmental Baseline*. 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 2009 p. 8), 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.

7.4.3.5 *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). 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 2009 pp. 5–6, 9). 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.

7.4.3.6 *Effects of Possible Sucker Relocation from Tule Lake Sumps*

During dry conditions with significant reductions in available surface water, elevations in the Tule Lake sumps may recede to levels that may adversely impact suckers in the sumps. If Reclamation and the USFWS, through discussions, deem it necessary to relocate suckers from Tule Lake, Reclamation, USFWS, and the Refuges will coordinate on a proposal to relocate suckers from the Tule Lake sumps before seasonally stressful water conditions develop. In the rare instance that dry winter conditions would precipitate sucker relocation from Tule Lake sumps, it is anticipated that approximately 500 adult suckers could be captured and relocated in a 2-week effort (Courter et al. 2010). With advance planning and additional effort, it is estimated that up to 1,000 adult suckers could be captured and relocated. In the previous effort, the observed short-term (i.e., within 48 hours after release) mortality from capture, transport, and release of adult suckers was less than 5 percent (Courter et al. 2010). If the mortality associated with the capture and relocation of 1,000 adult suckers from Tule Lake is double the previous short-term observation, then it is anticipated that 100 adult suckers could die as a result of stresses from capture and relocation.

In the unlikely event that a relocation effort is needed at the Tule Lake sumps, this action will result in an adverse impact to suckers through the stress of up to 1,000 individuals and the mortality of up to 100 individuals from the action of capture, transport, and release.

7.4.3.7 *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 the proposed action may increase risk of pelican predation on adult suckers. However, the proposed minima maintain some areas with sufficient water depths that reduce predation risk. Water quality is likely impacted by return flows from the Project, but the existing water quality conditions, which are not likely to significantly change, appear to be supporting sucker populations in Tule Lake

Sump 1A. The Project may also result in very small amounts of entrainment losses, which is not likely to impact the populations.

7.4.4 Effects to LRS and the SNS 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. There are very few age 1+ juvenile or adult suckers residing in the lower Lost River below Wilson Dam (USBR 2001b). No adult suckers were captured in the USGS 1999 effort below Wilson Dam.

Proposed operations were evaluated for potential effects to adult sucker spawning and migration, habitat for larvae and age-0 juveniles, habitat of older juveniles and adults, water quality, and the likelihood for entrainment.

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

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, Kirk et al. 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, may cause adverse impacts by changing the amount of habitat; however, flows during the spring spawning season are expected to be relatively high due to spring run-off and the beginning of the irrigation season. The primary impediment to migration during the spring is likely to be impoundments rather than flows. Additionally, since the USFWS has determined that the LRS and the SNS in this area are not necessary for recovery (USFWS 2013a), the proposed Project operations in the Lost River would not be considered to significantly affect the survival and recovery of the species.

7.4.4.2 *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 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 poor 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 are not necessary for recovery, the proposed Project operations in the Lost River would not be considered to significantly affect the survival and recovery of the species.

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

Older juvenile and adult suckers, mostly SNSs, reside in impounded areas or deep pools in the Lost River (Shively et al. 2000), 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 historical channelization that reduced connectivity and habitat quality (USBR 2009 pp. 3–6). 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. Reduced Lost River flows at the end of the irrigation season could increase 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. 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 influence habitat conditions in the Lost River for older juveniles and adult suckers. However, Project operations are not expected to adversely affect individual adult suckers because they reside primarily in the reservoirs and deep habitats (Shively et al. 2000 p. 83) that will be maintained even in low water conditions.

7.4.4.4 *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 (USBR 2009, Kirk et al. 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 they 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, Kirk et al. 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.

7.4.4.5 *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. Additionally, any sucker entrained from these diversions would have been previously entrained into the Lost River or canal system and would have been considered to be harmed and lost from the spawning populations upon initial entrainment. Based on this understanding of the system, 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.

7.4.4.6 *Summary of Effects to LRS and SNS Populations in the Lost River*

Based on the above analysis, the USFWS concludes the proposed action likely has several effects to suckers in the Lost River. Primarily, the action is expected to negatively affect the habitat conditions for all life stages of suckers through alterations to the natural variability of flows and by continuing to contribute to poor water quality conditions. Entrainment is also likely to occur but at a low level based on the low sucker densities. Since the USFWS has determined that the LRS and the SNS in this area are not necessary for recovery, the impacts from proposed Project operations in the Lost River would still be considered within the bounds of what will allow survival and recovery of the species as a whole.

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

The Lost River Subbasin 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 likely contains the largest SNS population. This unit provides resiliency and redundancy, two factors that are essential to maintaining and recovering imperiled species.

As described above, the proposed action is likely to have a variety of effects to the LRS and SNS populations in the Lost River subbasin recovery unit. Adverse effects of the proposed action on LRS and SNS that could affect survival and recovery in the Lost River Subbasin recovery unit include: (1) entrainment of suckers that likely occurs at Clear Lake Dam, Gerber Dam, and along the Lost River; (2) stranding of suckers at low lake levels in Clear Lake; and (3) agricultural return flows from the Project that likely reduce water quality in Tule Lake. There is also the small potential for an adverse impact to suckers in Tule Lake Sump 1A if a relocation operation is required.

Some elements of the proposed actions that will likely minimize adverse effects include: (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 2 cfs (0.028 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 irrigation season.

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.

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 poor water quality, entrainment, and stranding. These effects are unlikely to limit the persistence of LRS and SNS in the Lost River Basin because the events that cause these effects are rare, occur at an insignificant level, 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.

7.5 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 operation and maintenance (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 displacement; therefore the USFWS concludes that this proposed activity is compatible with the conservation needs of the species. This is explained below in detail.

7.5.1 Effects of Clear Lake Dam Maintenance

Reclamation states in their BA that each year before the start of irrigation season in March or early April, gates at Clear Lake Dam are typically opened to flush sediment that accumulates in front of the fish screen and dam (USBR 2018a pp. 7–31). 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.

7.5.2 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 2018a). 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 2018a). 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 the fish salvage, up to 1,500 age-0 and older juvenile suckers are captured through seining and electrofishing (Kyger and Wilkens 2011b, USBR 2018b). 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). Salvaged suckers were typically measured, tagged, and returned to UKL. Since 2016, salvaged suckers have been treated for inflictions by USFWS prior to tagging and releasing 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 (Korson et al. 2010), and mortality due to stranding would be expected in the absence of salvage.

Stranding of suckers in canals prior to or in absence of fish salvage likely results in additional mortality (Kyger and Wilkens 2011a), 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; presence of more fish 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 in which suckers will receive treatment prior to relocation to UKL. Additional detail on these effects is also provided above in Section 7.3.1.7.

7.5.3 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 2018a). Inspections require a drawdown of water within the channel and can occur at any time of the year. According to the BA, 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 draw down 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 with increased stress; if prolonged, these conditions could affect survival. However, adverse effects will likely be temporary (USBR 2018a). 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 can only enter the Lost River Diversion Channel through entrainment 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 (Section 7.3.1.7).

7.5.4 Effects of Link River Dam Fish Ladder Maintenance

As described in the proposed action, gates to the LRD fish ladder are exercised twice each year: once between January and April, and again between October and December. While the gates are exercised, the fish ladder is often dewatered and the entire structure is inspected. Fish are salvaged from the ladder while dewatered and returned to either the Link River or UKL. These activities have a short-term, temporary impact to suckers in and adjacent to the ladder that are expected to be insignificant. No more than five suckers of any life history stage have been encountered in the fish ladder during previous fish ladder inspections.

7.5.5 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 2018a). 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 2018a), 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 2018a).

Most canal, lateral, and drain maintenance occurs while canals are dewatered, and includes removal of sediment, vegetation, concrete repair, and culvert/pipe replacement (USBR 2018a). 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, USBR 2018b Appendix C), 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 2011b, Taylor and Wilkens 2013, USBR 2018b Appendix C).

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. 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, and treatment of fish at the USFWS rearing facility will increase the likelihood of survival of salvaged suckers. These effects are included in the discussion of entrainment in the UKL recovery unit above (Section 7.3.1.7).

7.5.6 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 2018a). Right-of-way and access maintenance may temporarily cause sedimentation into adjacent waterways, principally canals. When these activities occur, seasonal consideration and soil retention cloth are used to mitigate sedimentation of waterways. The effects of sedimentation and noise from these activities are likely to have an insignificant, temporary effect on individual suckers occupying adjacent waters.

7.5.7 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 2018a). Flushing the stilling wells occurs during the 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 2018a). The USFWS concludes effects of disturbance and temporary sedimentation from these activities are likely to have an insignificant effect on individual suckers occupying adjacent waters.

7.5.8 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, are likely to have a range of 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&M 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. It is 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, and treatment of fish at the USFWS rearing facility will increase the likelihood of survival of salvaged suckers. The adverse effects associated with dewatering of the Lost River Diversion Channel and other Project canals are considered in the effects of entrainment above.

7.6 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: (1) canal salvage; (2) assisted rearing; and (3) participation in sucker monitoring and the LRS & SNS Recovery Program. The effects of these measures on the LRS and the SNS are analyzed below.

7.6.1 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 2018b Appendix C). 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.

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 2011b, Taylor and Wilkens 2013). In recent years, the number of suckers salvaged from the canals has averaged around 300 individuals (USBR 2018b Appendix C). The ultimate fate of most salvaged suckers is unknown, but several lines of evidence suggest some survive and recruit into the adult population. Small numbers of 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 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. Additionally, since 2016 salvaged suckers have been taken to the sucker rearing facility where they receive treatment for any disease and parasites prior to release into a permanent waterbody. Although salvage is not without risks, especially because much of it is done by electroshocking, which can injure fish (Snyder 2003), those fish would not be expected to survive over winter in the dewatered canals without salvage.

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 is compatible with the conservation needs of the species.

7.6.2 Assisted Rearing

Reclamation proposes to provide funding to the USFWS to support assisted rearing 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 significant 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 disappearance of juvenile suckers from UKL beginning in August and extending into October (Burdick et al. 2018, Hewitt et al. 2018) accounts for this situation. An assisted rearing effort is needed to prevent extinction until the causes of juvenile mortality are addressed.

Specifically, Reclamation proposes to continue contributing approximately $300,000 per year to the USFWS that would be used for capital and operating costs associated with an assisted rearing program. Oversight of the assisted rearing program will continue to be provided by USFWS with input from the Klamath Sucker Recovery Program, in coordination with Reclamation. Reclamation's support of the assisted rearing program will continue for the term of this consultation (April 1, 2019 to March 31, 2024).

Assisted rearing was listed as necessary action in the original LRS and SNS recovery plan developed by the USFWS and was also identified as a need in the 2013 Revised Recovery Plan (USFWS 1993, 2013a). The Revised Recovery Plan recommends the development of an assisted rearing program when sucker populations in UKL reach a level of 25 percent of their estimated abundance in 2001-2002. This trigger has been met based on population data collected by USGS (Hewitt et al. 2018). Assisted rearing 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 assisted rearing will enable fish to survive past the most vulnerable early life stages with minimal risk of loss of genetic diversity. Assisted rearing 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 2015, the USFWS established the Klamath Basin Sucker Rearing Program as part of the 2013 BiOp and has raised wild-caught larvae in cooperation with a private aquaculture venture, Gone Fishing LLC, since 2016. Larval collections have been successful, and survival at the rearing facility has been high. Initially, the program relied exclusively on natural production in the rearing ponds to provide food for the captive suckers; however, it became clear in 2017 that growth rates were lower than anticipated and supplemental feed would be required to meet the target release size of 8 in (200 mm). The first cohort of 2,500 2-year old reared suckers was released in spring 2018. Prior to release, all of the fish were implanted with Passive Integrated

Transponder (PIT) tags that allow for remote detection of any reared fish that join the major spawning populations in UKL, which are both outfitted with PIT detection arrays. The fish are not likely to mature and spawn for several years, so a subset of 174 individuals were implanted with radio transponders prior to release to allow for monitoring of survival and movement during their first summer after release. Initial data indicate that the radio-tagged fish had high mortality. As noted above, fish did not initially receive supplemental feed and were undersized at an average of 6 in (146mm) at release, and the radio tags were larger relative to their body size than is recommended to avoid tag-related mortality. The 2017 cohort is expected to average around 8 in (200 mm) after 2 years, which is expected to reduce tag effects on survival and increase overall survival. Captive-reared June suckers in Utah Lake exhibited increased survival at larger sizes, and the minimum size at which some recruitment was observed was around 8 in (200 mm) (Rasmussen et al. 2009 p. 229, Billman et al. 2011 p. 485).

Assisted rearing 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 reared suckers have successfully recruited into the adult spawning populations (Modde et al. 2005, Marsh et al. 2005, Grabowski and Jennings 2009, Rasmussen et al. 2009, Billman et al. 2011). However, recruitment rates of repatriated suckers vary among rearing and acclimation strategies and depends on release size (Marsh et al. 2005, Rasmussen et al. 2009, Billman et al. 2011).

Based on the observed variability among rearing programs, the Klamath Basin Sucker Rearing Program is exploring a number of alternative rearing methods to determine which maximizes post-release survival and ultimately recruitment. For example, some of the 2017 cohort will be held in captivity for 3 years before reintroduction, and the program will also be experimenting with *in situ* rearing in net-pens in UKL. It is anticipated that comparisons among 2-year old releases, 3-year old releases, and *in situ* reared fish will clarify the methods that will maximize survival, and the program will be adjusted to focus on those methods.

At this time, it is difficult to fully assess the effects of assisted rearing on suckers because survival after reintroduction is poorly understood. However, based on the high captive survival and growth rates after adjustments to husbandry practices and based on the success with other sucker species, captive larval and juvenile survival rates clearly far exceed wild survival rates in UKL, which means that there is a beneficial effect on the individuals collected. Based on the results from other sucker propagation efforts discussed above, it is reasonable to assume that the increases in release size will result in survival to recruitment for some individuals released during the term of this BiOp. Based on rearing efforts under the 2013 BiOp and recent expansion of the facility, we expect that the funding provided by Reclamation as part of the conservation measures will support an average release of around 10,000 individuals per year. The annual release is likely to be lower than 10,000 for the first 2 years and higher thereafter. Assuming a post-release survival to recruitment of 10 percent for individuals between 200 and 300 mm (8 to 12 in; Billman et al. 2011 p. 485), this would result in recruitment of around 5,000 individuals released during the term of this BiOp. Given that the Environmental Baseline includes complete lack of LRS and SNS recruitment in UKL for the past two decades, these individuals are expected to substantially reduce the probability of extirpation of both species compared to the status quo (Rasmussen and Childress 2018 p. 6).

7.6.3 Effects of Recovery Implementation Team Participation and Sucker Monitoring

Reclamation proposes involvement and financial support in both monitoring of sucker populations and sucker recovery efforts, which builds on their past efforts. Reclamation anticipates annual funds of approximately $1.5 million per year, with an additional $700,000 for the first two years of the proposed action; additional funding will provided in later years as funds are available.

The Revised Recovery Plan for the LRS and the SNS (USFWS 2013a) called for the establishment of a Recovery Implementation Team to coordinate implementation of the final plan. Reclamation began work with USFWS, beginning in 2013, toward achieving the goals and objectives of the final revised recovery plan, which included dedication of resources for that purpose (USFWS 2013d). Reclamation's involvement and support of the Recovery Implementation Team greatly contributed 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. Based on shifts in personnel, the initial Recovery Implementation Team has not met recently, but USFWS has plans to restructure the sucker recovery effort to improve its focus on key priorities. Reclamation will participate and contribute funding to this effort in ways that will advance the needs of sucker recovery.

As part of the proposed action, Reclamation proposes to continue work on sucker monitoring, which Reclamation has funded since about 2000. Current efforts include UKL adult monitoring, Clear Lake adult monitoring, and juvenile cohort monitoring.

Reclamation's proposed commitments to recovery and monitoring are anticipated to contribute substantially to improvements to sucker populations and understanding of suckers. The overall effect of these actions is difficult to measure but is viewed as an essential component that leads toward survival and recovery of suckers.

7.6.4 Summary of Effects to LRS and SNS from Proposed Conservation Measures

The proposed conservation measures are anticipated to have beneficial effects that will minimize overall 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 assisted rearing over the duration of this BiOp will result in increased larval and juvenile survival for collected individuals and result in thousands of individuals recruiting into the adult population in UKL. Additional benefits will also be realized from the recovery and monitoring commitments and involvement from Reclamation, although the extent of those benefits are difficult to fully anticipate. All of these measures also serve to help offset the negative effects from other aspects of the proposed action.

7.7 Summary of Effects to LRS and SNS

The proposed action is anticipated to affect LRS and SNS through the storage and delivery of water, O&M activities, and conservation measures. Adverse effects to LRS and SNS populations as a result of the proposed action are likely to include: decreased habitat complexity for juvenile suckers in UKL under the lowest expected lake elevations, decreased availability of adult habitat in Clear Lake and UKL during low water years; decreased access to shoreline spawning habitat in UKL years with the lowest water levels; substantial entrainment of larvae and age-0 juveniles at the A Canal, Link River Dam, Clear Lake Dam, Gerber Reservoir Dam, and other Project infrastructure; stranding of suckers at low lake levels in Clear Lake; reduced water quality in Tule Lake due to agricultural return flows; entrainment or stranding of suckers during maintenance activities and canal dewatering at the end of the irrigation season. The Project operations may also result in decreased access to Willow Creek during years with moderate inflows and low lake elevations, but the relative roles of hydrology and Project operations are uncertain. There is also the small potential for an adverse impact to suckers in Tule Lake Sump 1A if a relocation operation is required.

Some elements of the proposed actions that will likely minimize adverse effects include: management of UKL elevations to limit surface elevations below the central tendency; minimum elevations in Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A; fish screens at the A Canal and Clear Lake Dam will likely reduce sucker entrainment; the 2 cfs (0.028 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 irrigation season; salvage efforts during maintenance and canal dewatering are anticipated to reduce sucker mortality and relocate suckers to a more suitable environment.

The proposed action is also likely to result in some beneficial effects to suckers Some beneficial effects of the proposed action are likely to include: water storage in winter in UKL, Clear Lake, and Gerber Reservoir that results in increases in sucker habitat in most years; increased Lost River flows during the irrigation season that will provide additional habitat; variable lake levels in UKL that could help maintain marsh vegetation; increased juvenile in UKL survival through assisted rearing; implementation of additional recovery actions through participation in the sucker recovery program.

Other effects from the Project are expected to be insignificant or discountable. For example, Project-related effects to age-0 juveniles in UKL that are unlikely to occur to during the term of this BiOp based on the low frequency of such conditions in the period of record.

7.8 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. There are no tribal lands within part of the action area that contains Lost River and shortnose suckers and their critical habitat. 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 non-Federal actions that are expected in the action area are habitat restoration, water quality improvements, and other actions that are regularly funded by Partners for Fish and Wildlife, the Oregon Watershed Enhancement Board, the National Fish and Wildlife Foundation, as well as through other entities. For example, past work has been done by the Klamath Basin Rangeland Trust, Klamath Watershed Partnership, The Klamath Tribes, The Nature Conservancy, Trout Unlimited, Sustainable Northwest, Klamath Soil and Water Conservation District, and Klamath Water Users Association. Funding has been consistent through these entities for years, but uncertainty always remains. Much of the uncertainty surrounding progress in ecosystem restoration is the willingness of private land-owning entities and persons to participate in voluntary restoration actions. However, given the amount of focused effort and the involvement of several key organizations in the Upper Klamath Basin, progress is expected toward the groups' priorities over the next 5 years that will be measurable at some scales.

We are unaware of other non-Federal activities within the action area that need to be considered in relation to this consultation. 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 life of the proposed action; however, none of the benefits can be quantified at this time because project details are limited and/or cannot currently be estimated.

8 STATUS AND ENVIRONMENTAL BASELINE OF CRITICAL HABITAT OF LOST RIVER SUCKER AND SHORTNOSE SUCKER

In this section, we assess the range-wide condition of LRS and SNS designated critical habitat. We describe factors relating to the condition of the physical and biological features (PBFs[1]) necessary for the survival and recovery of the species. We also present the

[1] Note: Past designations of critical habitat have used the terms "primary constituent elements" (PCEs), PBFs, or "essential features" to characterize the key components of critical habitat that provide for the conservation of the listed species. The new critical habitat regulations (81 FR 7214) discontinue use of the terms "PCEs" or "essential features" and rely exclusively on use of the term PBFs for that purpose because that term is contained in the statute. To be consistent with that shift in terminology and in recognition that the terms PBFs, PCEs, and essential habit features are synonymous in meaning, we are only referring to PBFs herein. Therefore, if a past critical habitat designation defined essential habitat features or PCEs, they will be referred to as PBFs in this document. This does not change the approach outlined above for conducting the "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs or essential features.

environmental baseline of the designated critical habitat, against which the effects of the proposed action will be assessed.

Designated critical habitat for LRS and SNS includes areas that are inside and outside of the action area (see Section 3). The areas of critical habitat inside the action area are primarily the lake and reservoir rearing habitats for all life stages. The areas of designated critical habitat outside of the action area are tributaries to UKL, Clear Lake, and Gerber Reservoir. These contain most of the designated spawning habitat. We only analyze the effects to designated critical habitat; however, this analysis also includes effects from upstream activities that could influence downstream critical habitat. For example, we will analyze operations of a dam upstream of critical habitat that affects flows into downstream critical habitat.

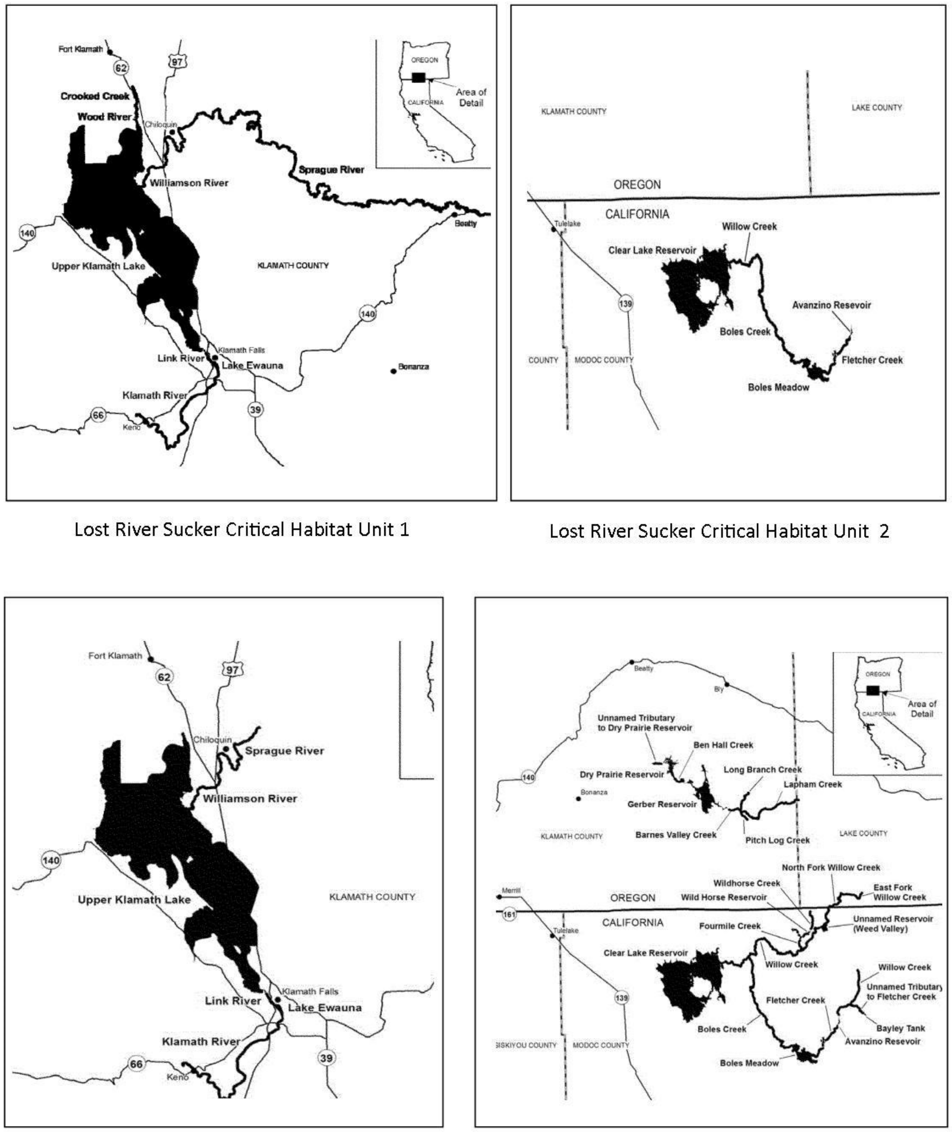
8.1 Legal Status

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). Designation of critical habitat for the LRS and the SNS was finalized on December 11, 2012, with publication of the final rule (USFWS 2012).

8.2 Critical habitat description

The critical habitat designation for LRS and SNS established two critical habitat units (CHUs) for each species, including a mix of Federal, State and private lands. Critical Habitat Unit 1, situated in Klamath County, Oregon, includes UKL and Agency Lake, the Link River, and Keno Reservoir 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 119 river miles (191 km). 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, Oregon (approximately river mile 75), whereas for the SNS, Unit 1 extends up the Sprague River only as far as the Braymill area near river mile 8.

Critical Habitat Unit 2 (the Lost River Basin) is situated in Klamath and Lake Counties, Oregon, and Modoc County, California (Figure 7-1). It includes Clear Lake Reservoir and its main tributary, Willow Creek as well as portions of Boles Creek, for both the LRS and the SNS. For the LRS, critical habitat includes Willow Creek to its confluence with Boles Creek and Boles Creek upstream to Avanzino Reservoir. For the SNS, critical habitat extends up Willow Creek beyond the Boles Creek confluence to include portions of the North Fork and East Fork of Willow and Fourmile, and Wildhorse Creeks in California. It also includes Boles Creek, Fletcher Creek, Willow Creek, and an unnamed tributary to Fletcher Creek. Gerber Reservoir and its main tributaries (Ben Hall and Barnes Valley Creeks) are also designated critical habitat in Unit 2 for SNS only. The total area for Unit 2 incorporates approximately 33,000 ac (13,355 ha) and 89 river miles (143 km) of reservoir and stream habitat.



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 8-1. Designated CHUs for the LRS and the SNS (USFWS 2012).

8.2.1 Conservation Role of Critical Habitat

Critical habitat contains those areas that are essential to the conservation of the species. The role of LRS and SNS critical habitat is to "support the life-history needs of the species and provide for the conservation of the species" (USFWS 2012 p. 73756).

8.2.2 Physical or Biological Features

When designating critical habitat, the Service considers physical or biological features (PBFs) "essential to the conservation of the species and which may require special management considerations or protection" (50 CFR §424.12; USFWS 2012 p. 73748). "These include, but are not limited to: 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" (USFWS 2012 p. 73748). The final critical habitat rule identified "accessible lake and river spawning locations that contain suitable water flow, gravel and cobble substrate, and water depth (as well as flowing water) that provide for larval out-migration and juvenile rearing habitat" as the essential PBFs for both LRS and SNS (USFWS 2012 p. 73750).

Based on our current knowledge of the habitat characteristics required to sustain the species' life-history processes, the PBFs essential for conservation of LRS and SNS are:

- PBF 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 the 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.
- PBF 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.
- PBF 3—*Food.* Areas that contain abundant forage base, including a broad array of Chironomidae, crustaceans, and other aquatic macroinvertebrates.

Threats identified in the critical habitat designation that may require special management considerations include (1) poor water quality; (2) potential entrainment at water diversion structures; (3) lack of access to essential spawning habitat; (4) lack of connectivity to historical habitat (i.e., migratory impediments); (5) degradation of spawning, rearing, and adult habitat; and (6) avian predation and predation by or competition with nonnative fish (USFWS 2012 p. 73750). These are discussed in detail in the final critical habitat rule.

8.3 Status and Environmental Baseline of Lost River sucker and shortnose sucker critical habitat

The critical habitat designation for LRS and SNS includes the majority of the locales occupied by one or both species. For this reason, the status of critical habitat for LRS and SNS overlaps substantially with the status and the environmental baseline of the species (see Section 6). More specifically, a summary of the status and environmental baseline of each PBF is provided below.

8.3.1 PBF 1 (Water)

This physical or biological feature can be summarized as sufficient water quantity and suitable water quality necessary to support the life history and to provide for the conservation of the species. Water quantity and water quality vary within and among sites and across multiple time scales. In general, the climate in recent years has been drier than average, which can limit the water needed to meet the needs of the species (see Section 6.5.2), including connectivity to spawning areas, particularly the UKL shoreline springs (Burdick et al. 2015b) and tributaries to reservoirs in the Lost River Basin (Hewitt and Hayes 2013). Water quality is poorer for UKL and Lake Ewauna compared to other designated critical habitat (Clear Lake Reservoir and Gerber Reservoir), though data for the latter are comparatively sparse (see Section 6.5.3).

8.3.2 PBF 2 (Spawning and Rearing Habitat)

Spawning habitat exists at the UKL shoreline springs, Williamson River, Sprague River, Willow Creek, Boles Creek, Barnes Valley Creek, and Ben Hall Creek (see Sections 6.2 and 6.3). Of these, only the UKL shoreline springs occur within the action area. As discussed above, the UKL shoreline springs may also become desiccated to some degree if lake levels drop substantially during the spawning season. Overall, spawning habitat has decreased compared to historical conditions, in terms of either actual spatial extent or functioning.

Rearing habitat is present within UKL, Clear Lake Reservoir, and Gerber Reservoir, as well as their tributaries, and the majority of rearing habitat occurs within the action area. Limited documentation of rearing of suckers in the tributaries indicates this can occur (Hayes and Rasmussen 2017, entire), but it is unclear to what extent this occurs in any of the populations. Larvae and juveniles primarily utilize vegetated areas along the fringes of UKL until they move into the deeper areas of the lake as they grow (see Sections 6.2.3 and 6.2.4). However, in Gerber and Clear Lake Reservoirs very little of this type of habitat exists in some years; nevertheless, juveniles are able to survive to recruit to adults with regularity. It is unknown whether the scarcity of emergent vegetated habitat affects the proportion of individuals that rear in the tributaries or whether the fish simply exploit other niches within the lake.

It is difficult to quantify the extent and quality of existing rearing habitat. Less rearing habitat certainly exists compared to historic levels and many of the remaining areas have been modified so that the habitat is not functioning in the same ways it did historically (see Section 6.5.1).

8.3.3 PBF 3 (Food)

Very little empirical data exists on the quantity, quality, and availability of food throughout the designated critical habitat, but the available data suggest large quantities of food are available (Stauffer-Olsen et al. 2017).

8.4 Environmental baseline of Lost River sucker and shortnose sucker critical habitat

Much of the information regarding the environmental baseline for the critical habitat for LRS and SNS is presented in Section 6.5 – The Environmental Baseline for the species. The sections covering habitat (6.5.1), water quantity (6.5.2), water quality (6.5.3), climate (6.5.7), environmental contaminants (6.5.8), predation (6.5.9), and disease and parasites (6.5.10) are directly applicable to specific aspects of critical habitat.

Overall, the habitat of the species has been lost or degraded in numerous ways that are likely to reduce the capacity of the habitat to support the life history and provide for the conservation of LRS and SNS. In Critical Habitat Unit 1, the environmental baseline of poor water quality is of particular note because it creates stressful conditions for juvenile and adult suckers annually in late summer. In Critical Habitat Unit 2, water quantity as it relates to spawning access is especially important, particularly in Clear Lake. Low streamflow and/or lake elevations during the spawning season can limit access to spawning habitat such that the habitat does not provide its function of supporting reproduction.

8.4.1 Consulted on Effects to Designated Critical Habitat

Consultations on effects to designated critical habitat are discussed in Section 6.5.11. Specifically, consultations regarding grazing on the Fremont-Winema National Forest (6.5.11.3), widening of highway 140 (6.5.11.4), and issuance of scientific permits (6.5.11.5) are directly relevant. No actions since the final designation of critical habitat have been determined to constitute adverse modification of critical habitat.

9 EFFECTS OF PROPOSED PROJECT OPERATIONS TO LRS AND SNS CRITICAL HABITAT

In this section, we analyze the effects of proposed Project operations on three PBFs: (1) water; (2) spawning and rearing habitat; and (3) food as described in Section 8. Given the nearly universal disappearance of age-0 juvenile suckers from UKL beginning in August and extending into October (Burdick et al. 2018) 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 more stable, more variation in the quality of PBF function can occur and still adequately support the conservation of the suckers.

9.1 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 (USFWS 2012). This unit also includes critical habitat designated downstream of Link River Dam at the outlet of UKL to Keno Dam (USFWS 2012).

9.1.1 Effects to LRS and SNS Critical Habitat in UKL and its Tributaries

9.1.1.1 *Effects to PBF 1: Water*

Both water quality and water quantity are important to the water PBF. As described above in Section 7.3.1.6, 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, 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 for LRS and SNS, as discussed in Section 7.1.3.6, the USFWS finds there are no causal links between Project operations and water quality.

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, and these effects are expected to be insignificant.

In contrast to water quality, water quantity is directly affected by the proposed action, with UKL elevations expected to be generally higher in the winter and spring and lower in the late summer and fall than historical conditions prior to the construction of Link River Dam. The effects of water depth manipulation under the proposed action on LRS and SNS habitat are described in Sections 7.3.1.1-7.3.1.5. Effects to spawning and rearing habitat due to water depth are discussed in the following section. Overall, the proposed action is expected to provide adequate water depths to provide preferred habitat and access to water quality refugia in almost all years. However, in water years similar to the driest years in the POR, shallow water is expected to reduce the amount of habitat available in the preferred depth range for adults. Such conditions are anticipated to be quite rare under the proposed action and are not expected to result in long-term changes to the habitat.

9.1.1.2 *Effects to PBF 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 tributary spawning sites are upstream of the reaches of these rivers affected by UKL elevations.

The proposed action could have significant effects on spawning habitat at groundwater seeps along the eastern shoreline of UKL because habitat availability is reduced at lake elevations less than around 4,142 ft (1,262.5 m) during the spring spawning months (Burdick et al. 2015b pp. 483–484). In general, implementation of proposed Project operations over the term of this BiOp 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 7.3.1.1, sucker spawning and larval rearing habitat is likely to be greatly reduced only at the lowest lake levels and those elevations occurred in 3% of modeled years with minor impacts to spawning habitat in 11% of years. Because LRS and SNS are long-lived species, occasional reduction in the spawning success should not significantly impact the ability of the habitat to support the survival and recovery of the species.

The critical habitat designation specifically refers to "areas containing emergent vegetation adjacent to open water" (USFWS 2012 p. 73750) to provide rearing habitat for larval LRS and SNS as discussed in Section 7.3.1.3. As larvae transition to juveniles, which occurs by late July, they utilize a variety of habitats but appear to select for shallow water (Buettner and Scoppettone 1990, Burdick et al. 2008 pp. 425, 427). Therefore, availability of emergent vegetation is most important up to around July 15. Based on model output, the proposed action provides at least 50% of possible wetland edge habitat in 86% of years, and at least 30% of possible wetland habitat is expected to be inundated in 97% of years. In the lowest water years, the proposed action is expected to have an adverse impact on the ability of critical habitat to provide adequate rearing habitat as part of the intended recovery role for the species.

The effects of the proposed action on juvenile LRS and SNS habitat are described in Section 7.3.1.4 and indicate that the function of the habitat would be adversely affected in years when lake levels are extremely low, which would diminish its ability to provide essential habitats to juvenile suckers. However, such conditions are anticipated to be rare under the proposed action, with less than 30% of the habitat available in approximately 3% of years, making it unlikely that this would occur during the 5-year term of this BiOp.

9.1.1.3 *Effects to PBF 3—Food*

UKL is a highly productive lake and has high densities of invertebrates on which LRS and SNS feed (Stauffer-Olsen et al. 2017 p. 263), and the proposed action is not expected to alter food availability. Growth data from juvenile suckers in UKL suggest that food availability is not a limiting factor (Burdick et al. 2015a p. 49). 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. Therefore, we do not expect effects to PBF 3 in UKL and its tributaries as a result of implementation of the proposed action.

9.1.2 Effects to LRS and SNS Critical Habitat at Keno Reservoir

9.1.2.1 *Effects to PBF 1—Water*

The proposed action has much more of an effect on water quality in Keno Reservoir than in 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, Kirk et al. 2010). Drain water coming from the Project contains high concentrations of nutrients and degrades water quality in the vicinity of the Straits Drain at the south end of the reservoir (Kirk et al. 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. However, diversion appears to result in a net reduction in nutrient loading to Keno Reservoir by rerouting nutrient rich water from UKL (Kirk et al. 2010). To the degree that the Project contributes to poor water quality in Keno Reservoir, the 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. The relatively constant surface elevations mean that existing habitat is always available, including large areas of emergent vegetation.

9.1.2.2 *Effects to PBF 2—Spawning and Rearing Habitat*

There is an anecdotal report of suckers spawning in the lower Link River; in May 2007, 10 suckers were seen showing behaviors associated with spawning (Smith and Tinniswood 2007). It is not clear whether this is a regular occurrence due to the low numbers and single observation, but this area is not believed to support successful spawning (Simon et al. 2014 p. 72). There is no other known spawning habitat between the Link River and Keno Dam. Based on these considerations the proposed operation of the Link River Dam for downstream water needs is not anticipated to affect spawning habitat (PBF 2) downstream of Link River Dam.

Stable water levels can reduce wetland establishment and regeneration because flooding redistributes seeds and many wetland plants require a period of drying to germinate (Middleton 1999 pp. 99–133). Thus, management 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 that are important for young suckers. Although this effect to PBF 1 is likely adverse, there is abundant marsh vegetation available relative to the number of larval and juvenile suckers present in Keno Reservoir, and stable surface elevations do inundate 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 an adverse but relatively minor effect on the recovery-support function of critical habitat PBF 2 for the LRS and the SNS in Keno Reservoir.

9.1.2.3 *Effects to PBF 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 expected to affect the recovery-support function of critical habitat to provide food for the LRS and the SNS in the Keno Reservoir.

9.1.3 Summary of Effects to LRS and SNS Critical Habitat Unit 1

There is no causal link to adverse effects to water quality (PBF 1) in UKL; however, there is evidence that water diversions through the Project cause a net reduction in nutrients downstream of UKL, which is beneficial. 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. However, given the large inputs of nutrients and organic matter from UKL, it is unlikely that these effects would result in a measurable difference in the parameters most important to suckers, such as dissolved oxygen, and are therefore considered insignificant.

Spawning and rearing habitat (PBF 2) in UKL are expected to be adequate in almost all years under the proposed action. However, years with the lowest lake elevations in the model POR resulted in significant reductions in available spawning habitat at the lakeshore springs and in emergent wetland habitat available for larval rearing.

The proposed Project does not affect food availability (PBF 3) in Unit 1.

9.2 Effects to LRS and SNS Critical Habitat Unit 2

Critical habitat designated for the LRS and the SNS in Unit 2 includes Clear Lake and its main tributary, Willow Creek; critical habitat designated only for the SNS includes Gerber Reservoir and its main tributaries. 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 (USFWS 2012 pp. 73753–73755).

9.2.1 Effects to LRS and SNS Critical Habitat at Clear Lake and in Willow Creek

9.2.1.1 *Effects to PBF 1—Water*

At Clear Lake, the proposed action is not likely to result in water quality conditions that are outside the suitable ranges for suckers (discussed in Section 7.4.1.4 in more detail). Overall, 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). As historic operations are not changing, 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.

The proposed action does affect water quantity through the management of Clear Lake for irrigation deliveries. In general, water levels in Clear Lake are likely higher than before the construction of the dam in 1910. However, due to high evaporative losses from the shallow lake and highly variable hydrology, there is substantial interannual variation in lake elevations. As discussed in Section 7.4.1.1, low lake elevations can make the habitat less suitable by reducing connectivity between Clear Lake and the spawning habitat in Willow Creek and making the east lobe unsuitable. Low lake elevations have been somewhat more common in recent decades than in the period of record, which dates back to 1911. For example, lake elevations have been below 4,524 ft, (1,378.9 m) the elevation required for access to spawning habitat via Willow Creek, in 65% of years at the end of January and 35% of years at the end of February between 1999 and 2018, which is much higher than the rest of the period of record. Whether low lake elevations can preclude access to Willow Creek in years with sufficient stream flow to support spawning is a critical uncertainty that needs to be resolved to confirm this assumption. In summary, the proposed action is likely to adversely affect critical habitat in Clear Lake by the extent of suitable habitat, particularly when the east lobe becomes unsuitable below 4,523 ft (1,378.6 m).

9.2.1.2 *Effects to PBF 2—Spawning and Rearing Habitat*

Although access to spawning habitat in Willow Creek and its tributaries can be reduced at low lake elevations, the proposed action has no effect on the spawning habitat itself, which is outside the action area.

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, affecting components of PBF 2. The amount of rearing 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, and evaporation and leakage are high because of the shallow depths and large surface area of the lake. At the lowest lake elevations, habitat in the east lobe is not accessible and the overall area of habitat is reduced. 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 5-year term of this BiOp.

The minimum lake elevation being proposed for Clear Lake (i.e., 4,520.6 ft) has been used to guide operations for decades. Recent monitoring data shows evidence of frequent recruitment (Hewitt and Hayes 2013, D. Hewitt USGS personal communication), suggesting that the operations have supported the recovery function of the rearing habitat. Therefore, it appears although droughts and resulting low lake levels are likely to have adverse effects at the time they occur, these are not likely to be persistent effects that impact the overall recover function of PBF 2.

9.2.1.3 *Effects to PBF 3—Food*

No specific data concerning the availability of food in Clear Lake exists. The reservoir contains a very large amount of habitat and is productive enough to maintain dense populations of zooplankton. There will be no significant change from historic operations; therefore, food availability is not expected to be altered by the proposed action. We expect no effect to the recovery-support function of critical habitat PBF 3 for the LRS and the SNS in Clear Lake as a result of implementation of the proposed action.

9.2.2 Effects to SNS Critical Habitat in Gerber Reservoir and Its Tributaries

9.2.2.1 *Effects to PBF 1—Water*

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). 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 low lake surface elevations because shallower depths would likely increase mixing of bottom waters and thus 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 there is no clear link between Project operations and algal blooms. Therefore, any effects are likely to be insignificant.

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.

The proposed action does not affect PBF 1 in the tributaries of Gerber Reservoir because Project operations do not extend to the tributaries. However, access to Ben Hall and Barnes Valley Creeks, which are the two main Gerber Reservoir tributaries where SNS spawning occurs, could potentially be limited by low reservoir elevation during the February through May spawning season. Past consultations have contended that an elevation of at least 4,805.0 ft (1,464.6 m) provides access, but after reviewing the literature, the basis for this claim is not clear. 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 2018a Appendix 6B). The consistent presence of a broad size distribution of adult SNS containing individuals from multiple year classes indicates that successful spawning is occurring regularly and resulting in recruitment (Barry et al. 2007, Leeseberg et al. 2007, B. Phillips USBR personal communication May 10, 2018), suggesting that the recovery function of the habitat has been maintained under recent management. Continuing to manage the reservoir as it has been managed in the past is expected to provide similarly suitable habitat conditions.

Based on the presence of a broad size distribution representing multiple year classes in Gerber Reservoir and the fact that proposed Project operations will be unchanged from past operations, PBF 1 is expected to continue to function as intended, and the effects of Project operations on PBF 1 are expected to be insignificant.

9.2.2.2 *Effects to PBF 2—Spawning and Rearing Habitat*

The proposed action is not anticipated to impact spawning habitat in tributaries to Gerber Reservoir, the first component of PBF 2.

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. Still, the presence of broad size distributions with multiple year classes indicates that recent habitat conditions support frequent successful spawning and recruitment (Barry et al. 2007, Leeseberg et al. 2007, B. Phillips USBR personal communication May 10, 2018). Thus, maintaining the current management strategy is not expected to result in adverse effects.

9.2.2.3 *Effects to PBF 3—Food*

No specific data concerning the availability of food in Gerber Reservoir exists. The reservoir contains a very large amount of habitat and is productive enough to maintain dense populations of zooplankton. Food availability is not expected to be affected by the proposed action;

therefore, PBF 3 will continue to support the recovery-support function of critical habitat for the SNS in Gerber Reservoir under the proposed action.

9.2.3 Summary of Effects to LRS and SNS Critical Habitat Unit 2

In Clear Lake, the proposed action is likely adversely affecting rearing habitat (PBF 2) and adult habitat (PBF 1) during droughts that are likely to occur once during the term of this BiOp. Though Project operations are unlikely to limit spawning access (PBF 1) in wet and dry years, impacts in moderately wet years remain uncertain. No effects are expected to food availability (PBF 3). However, these effects are unlikely to impede the recovery-support function of critical habitat for the LRS and SNS in Clear Lake.

In Gerber Reservoir, effects to PBFs of critical habitat as a result of the implementation of the proposed action are expected to be insignificant, and we expect Gerber Reservoir to continue serving its recovery-support function as critical habitat.

Overall, we conclude that Unit 2 of critical habitat is supporting the recovery role for the LRS and SNS.

9.3 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 7.6 of this document, *Cumulative Effects* to LRS and SNS, are the same actions considered for cumulative effects to critical habitat for LRS and SNS. The actions listed in Section 7.6 will improve water quantity, water quality, and habitat in areas that support listed suckers, including UKL and its tributaries and the Keno Reservoir. 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, specifically PBF 1 in Critical Habitat Unit 1. These future State, tribal, and private actions are anticipated to result in beneficial cumulative effects to critical habitat for LRS and SNS over the term of this BiOp (5 years); however, none of the benefits can be quantified at this time because specific project details are not available.

10 JEOPARDY AND DESTRUCTION OR ADVERSE MODIFICATION DETERMINATION

After reviewing the current status of the LRS and the SNS, the environmental baseline, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the continued operation of the Klamath Project is not likely to jeopardize the continued existence of the LRS and the SNS or result in the destruction or adverse modification of critical habitat. The Service reached this conclusion based on the factors analyzed in sections 6 through 9 above, which are summarized below.

10.1 Jeopardy Analysis

10.1.1 Range-wide Status of the LRS and SNS and the Environmental Baseline in the Action Area

In Section 6, we described the factors that have led to the current status of the LRS and SNS as endangered throughout their range under the ESA, and particularly the threats identified at the time of listing (e.g., habitat loss, non-native species, and water quality) and new threats identified since listing (e.g., introgression, climate change, parasites, and diseases). These factors, along with others, are affecting the current status such that there is a lack of resiliency and redundancy due to reductions of self-sustaining populations range-wide, dramatic population declines in UKL, and loss of important habitats and populations in large parts of their range (USFWS 2013a). Reproducing populations of SNS remain in three locations (UKL, Clear Lake, and Gerber Reservoir), and reproducing LRS populations remain in two (UKL and Clear Lake). The only populations with frequent recruitment are SNS occurring in Gerber Reservoir and Clear Lake. LRS in Clear Lake show some recruitment, but recruitment is highly variable in magnitude. 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. In sum, the only populations with regular recruitment are SNS in Clear Lake and Gerber Reservoir.

We include some additional details on the UKL populations here because the status is more tenuous and dynamic than those in the Lost River recovery unit. Specific factors limiting LRS and SNS resilience 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. Still, recent survival rates of adult suckers in UKL have been relatively high (Hewitt et al. 2018), though initial data suggest that survival between spring of 2016 and 2017 was lower than usual. 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 the current old age of existing adults, both species will be at a high risk of extirpation without recruitment. A die-off of adult suckers in UKL, similar to those that occurred in the 1990s, could be catastrophic, especially for SNS because of its low abundance. It is also possible that the low adult survival rates from the most recent year available could portend an increase in mortality due to senescence, but additional years of data will be necessary to evaluate this hypothesis. Regardless, their continued survival in UKL depends on recruitment in the near future.

In our *Environmental Baseline* (Section 6.5), we described conditions and past actions that currently adversely affect the LRS and SNS within the action area, including: (1) negative effects of water quality (e.g., low DO, high ammonia, high pH, algal toxins, and urban and agricultural run-off) to suckers in UKL, Keno Reservoir, Lost River, Tule Lake, and the Klamath River; (2) native and introduced pathogens, parasites, and predators; (3) injury and mortality associated with entrainment into irrigation canals, turbines, and spillways at water control structures and dams; (4) migration barriers such as dams that prevent access to upstream spawning habitats in the Lost River and the Klamath River and adverse water quality and low flows that could also act as seasonal barriers; and (5) diversion of water for agriculture and drought that can reduce the access to and availability of spawning and rearing habitats throughout their range, especially during droughts when water use increases.

Conversely, conservation efforts and restoration activities have been implemented and are ongoing in an effort to improve the environmental baseline for suckers, either directly or indirectly. Enforcement of State water-quality criteria and State water rights upstream of Project reservoirs that contain suckers; implementation of management plans associated with the Total Daily Maximum Loads (TMDL); and on-going restoration/enhancement of sucker habitat 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 assisted rearing program will have beneficial effects to the individuals that are collected by increasing survival above observed rates in UKL, which are annually close to zero; this is anticipated to enable recruitment of some individuals into the adult sucker populations in UKL by stocking individuals in size classes that should have higher survival. Overall, the environmental baseline for the species in the action area is highly degraded and is contributing to their current endangered status; conservation efforts and restoration activities are anticipated to provide benefits to suckers and their habitats.

10.1.2 Summary of Effects to LRS and SNS

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 2013a). The proposed action affects LRS and SNS in both recovery units (UKL and Lost River Basin), and each of the eight management units therein, though effects to the management unit downstream of Keno Dam are less substantial than at the other seven units.

10.1.2.1 *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 2013a). As described in the *Effects of the Action* (section 7), 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.

Adverse effects of the proposed action to LRS and SNS in UKL Recovery Unit are expected to include:

- Low lake elevations in some years may limit access to spawning habitat at the UKL shoreline springs

- In UKL, diversion of water during dry years will decrease habitat availability for larvae in early summer and for juvenile and adult suckers in late summer
- 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
- Dewatering of canals as part of seasonal O&M operations at Project facilities is expected to strand any age-0 juveniles present and make them vulnerable to bird predation.

Beneficial effects of the proposed action to LRS and SNS in the 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) in most years
- 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.

Aspects of the proposed action, including Conservation Measures, that will likely minimize impacts of the Project to LRS and SNS in UKL Recovery Unit 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, thereby minimizing entrainment effects
- Financial and technical support for the assisted rearing program identified in the Conservation Measures will enable continued rearing of suckers and will result in the production of substantial numbers of juveniles larger than 8 inches that are likely to have substantially higher survival rates than larvae and age-0 suckers. The benefit of increased larval and juvenile survival for the reared individuals serves to indirectly offset the loss or injury of larval and age-0 suckers that may be adversely affected by the proposed action. The program is also likely to increase recruitment of suckers in to the adult populations in UKL, though the magnitude of this change is uncertain.
- Participation and support by Reclamation for the sucker Recovery Program identified in the Conservation Measures is expected to help offset adverse effects of the proposed action by advancing the planning and implementation of sucker recovery efforts other than assisted rearing.
- Water will be managed according to the decision rules outlined in the proposed action to provide variable UKL elevations dependent upon actual and forecasted inflows and water use conditions.

10.1.3 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 2013a). SNS are found throughout the Lost River subbasin with the largest populations occurring in Clear Lake and Gerber Reservoir. LRS are represented by a small population in Clear Lake. LRS are rare in the Lost River and LRS do not occur in Gerber Reservoir. Small populations of LRS and SNS occur in Tule Lake Sump 1A. As described in the *Effects of the Action* (Section 7), the proposed action could have a variety of effects to the LRS and SNS. These effects are summarized below.

Adverse effects of the proposed action on LRS and SNS in the Lost River Basin Recovery Unit are expected to include:

- Diversion of water from Clear Lake for agriculture decreases habitat availability for all life-history stages and may strand small numbers of individuals at the lowest expected elevations
- A portion of suckers entrained into Project facilities at Clear Lake, Gerber Reservoir, Tule Lake, and in the Lost River are likely to be injured or killed
- 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.

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

Aspects of the proposed action, including Conservation Measures, that minimize impacts to LRS and SNS in the Lost River Basin Recovery Unit, include:

- The Clear Lake fish screen reduces entrainment of juvenile suckers and prevents entrainment of adult
- Maintenance of seasonal water levels in Tule Lake provides 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.
- Management of irrigation deliveries from Clear Lake and Gerber Reservoir to avoid lake elevations below the proposed minima will limit adverse effects of reductions to available habitat or restricted access to spawning tributaries.
- Maintaining flow in Miller Creek through the frost valve at Gerber Reservoir will minimize stranding of suckers.

The USFWS concludes, based on our analysis of the effects of the proposed action presented in the *Effects of the Action* (Section 7) and summarized above, the most substantial effect 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. Recruitment in UKL is limited by unknown factors, but any reduction in juveniles that could subsequently recruit is a concern.

The most substantial effects of the proposed action to LRS and SNS in the Lost River Basin Recovery Unit are likely to be the seasonal loss of habitat resulting from water diversions from Clear Lake during infrequent prolonged droughts and entrainment at Clear Lake Dam and Gerber Reservoir Dam. The best available information indicates that Project operations will not be a limiting factor for spawning in dry years, when streamflow will preclude spawning, or in wet years, when rapid increases in lake elevations should provide access even following relatively low lake elevations in the all. However, uncertainty remains about Project effects in moderately wet years.

10.1.4 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 6), 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, which can only occur when there is adequate survival of all life stages from embryos to adults.

Currently in UKL, the primary limiting factor 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 the primary factor putting LRS and SNS populations at risk of extirpation in UKL, there are two aspects of the effects analysis that deserve particular attention: 1) is the proposed action contributing to the annual juvenile disappearance? 2) Are effects to the remaining adults small enough to allow for the continued production of larvae to support assisted rearing and the possibility of natural cohort survival if conditions allow?

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 age-0 juveniles are present, are artificially increased by Reclamation in order to provide water for irrigation. Loss of age-0 juveniles is more of a concern than loss of larvae because juveniles should have a greater likelihood of recruiting into the adult population than larvae. Based on this, entrainment of young suckers is likely to affect population viability. However, the effect of assisted rearing as a minimizing factor also needs to be considered in the overall effect of the proposed action on population viability.

Reclamation has committed to provide funding for a multi-faceted assisted rearing program. The Reclamation-funded portion of this program, as implemented by USFWS, is intended to minimize the effects of the proposed action on LRS and SNS populations – not to produce sufficient suckers to achieve recovery. Though mortality is expected during collection and rearing of suckers, overall survival during collection and in captivity is expected to be much higher than in the wild, and survival of reared fish after release back into UKL is also expected to be much higher than that of larvae and age-0 juveniles, as discussed in detail in Section 7.6.2. Therefore, assisted rearing is anticipated to have beneficial effects to larval and juvenile survival while fish are in captivity and ultimately result in some recruitment of new individuals to the adult populations after stocking, which will have positive effects on population viability.

Based on observed high adult survival across a wide range of lake elevations, Project operations are not expected to appreciably reduce adult sucker survival in UKL. There is a chance of adverse effects to reproductive output at the shoreline springs; however, the probability of observing such conditions in the 5-year term of the BiOp is low. Additionally, it is expected that overall larval production would still be large under such conditions given that the maximum impact to reproduction at the shoreline springs is expected to be around 35%, and there would be no impacts to spawning in the Williamson River where a large majority of the suckers spawn. Therefore, the effects of the proposed action on adult survival and spawning are not expected to reduce population viability.

At Clear Lake and Gerber Reservoir, SNS appear to be experiencing frequent recruitment. Although we do not have sufficient data to evaluate whether recruitment rates are sufficient to offset adult mortality, the proposed action is consistent with operations that have sustained these populations over the past decades, so it not likely to significantly affect viability. The population of LRS in Clear Lake appears to be in a more tenuous state, with variable recruitment and the apparent loss of some cohorts as older juveniles or young adults. Because we do not fully understand LRS and SNS habitat needs and the hydrologic conditions that allow for access to Willow Creek, adverse effects of lake-level management on LRS in Clear Lake cannot be ruled out. Resolving this uncertainty is critically important to ensure the conservation of endangered suckers in Clear Lake; however, based on the best available information, the proposed action does not appear likely to reduce the viability of the sucker populations in Clear Lake and Gerber Reservoir.

10.1.5 Summary of Cumulative Effects

Future non-Federal actions within the action area are expected to result in beneficial effects. Specifically, increased screening should reduce entrainment into irrigation diversions, habitat restoration is expected to improve habitat availability and water quality, and the Klamath Tribes' sucker rearing efforts are anticipated to increase recruitment to the UKL sucker populations.

10.1.6 Synopsis of Non-Jeopardy Determination

The USFWS' non-jeopardy determination for the effects of the proposed action on the LRS and SNS is based on the following. The small number of remaining LRS and SNS populations, the status of the LRS and SNS populations in UKL, and the status of the Clear Lake LRS population suggest that further reductions in the resilience of populations in UKL, Clear Lake, or Gerber Reservoir raise concerns for the ability of the species to recover. Survival is expected to continue to be influenced by Project activities such as entrainment; however, larval and juvenile survival are expected to increase due to assisted rearing and conservation measures implemented as part of the proposed action. The highly degraded state of the environmental baseline and status of LRS and SNS was apparent throughout this consultation. As a result, Reclamation coordinated extensively with USFWS during development of the proposed action (See Consultation History). That effort resulted in a proposed action that includes higher seasonal UKL elevations, particularly in summer and fall, and greater certainty that expected elevations will be met compared to previous proposed actions. Higher seasonal UKL elevations are important to provide habitat for larval, juvenile and adult LRS and SNS. However, substantial adverse effects 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 and maintain or improve resilience and redundancy. 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. In particular, assisted rearing is expected to increase the survival of larvae and juveniles that are brought into captivity and, based on preliminary results and results from other sucker propagation efforts, we expect that some of the large juvenile suckers released from the program are likely to survive and recruit into the adult populations, increasing the resilience of the UKL populations.

Based on our analysis, 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.

10.2 Destruction or Adverse Modification of Critical Habitat

In accordance with policy and regulation, the destruction or 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 physical or biological features (PBFs), factors responsible for that condition, and the intended recovery function of the critical habitat overall, as well as the intended recovery function in general for 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 evaluates direct and indirect impacts of the proposed Federal action and effects of any interrelated or interdependent activities on the PBFs 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 PBFs and how that will influence the recovery role of affected critical habitat units.

The destruction or adverse modification analysis determines if the PBFs 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.

10.2.1 Summary of the Status of LRS and SNS Critical Habitat

PBF 1 is water quantity and quality. The two critical habitat units have a similar status with respect to water quantity. Namely, water quantity across days, seasons, and years, and low lake elevations or streamflow can reduce the recovery support function of the critical habitat by reducing availability of and access to suitable habitat. The water quality component of PBF 1 appears to be functioning in Critical Habitat Unit 2; however, water quality is highly degraded in Critical Habitat Unit 1.

PBF 2 is spawning and rearing habitat. Spawning habitat is largely functioning as intended in both critical habitat units. However, low streamflow conditions in the tributaries to Gerber Reservoir and Clear Lake in Unit 2 can reduce the ability of the habitat to support successful reproduction. Similarly, some of the habitat at the UKL shoreline springs in Unit 1 occasionally becomes unusable due to low lake elevations. Rearing habitat has been greatly reduced from historical levels in Unit 1 through the draining of wetlands. Thousands of acres of emergent wetlands still exist, but these can become largely unavailable at very low lake elevations. Although Clear Lake and Gerber Reservoir are largely devoid of emergent vegetation, both reservoirs exhibit regular recruitment, suggesting that the habitat is serving its recovery support function.

PBF 3 is food. Although food availability has not been specifically evaluated across all of the critical habitat, the upper Klamath basin is highly productive, and all of the critical habitat appears to contain an abundant forage base.

10.2.2 Summary of the Environmental Baseline of LRS and SNS Critical Habitat

Overall, the habitat of the species has been lost or degraded in numerous ways that are likely to reduce the capacity of the habitat to support the life history and provide for the conservation of LRS and SNS. In Critical Habitat Unit 1, the environmental baseline of poor water quality is of particular note because it creates stressful conditions for juvenile and adult suckers annually in late summer. In Critical Habitat Unit 2, water quantity as it relates to spawning access is especially important, particularly in Clear Lake. Low streamflow and/or lake elevations during the spawning season can limit access to spawning habitat such that the habitat does not provide its function of supporting reproduction.

10.2.3 Summary of Effects to LRS and SNS Critical Habitat

In our *Effects of the Action on LRS and SNS Critical Habitat* (Section 9) of this BiOp we described how the proposed action was likely to affect the PBFs essential to the conservation of LRS and SNS in the two critical habitat units (UKL and Lost River Basin).

The primary effects of the proposed action on critical habitat are to PBFs 1 (water) and 2 (spawning and rearing habitat) through 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, resulting in beneficial, adverse, and insignificant effects. For UKL, the proposed action was designed to provide lake levels that provide availability of important habitats, which is often a result of managing water. Specifically, end of season targets are higher, providing more habitat in summer and fall than under previous operations. Additional operational rules, such as the UKL credit and the central tendency, provide greater assurance than previous proposed actions that lake elevations will not be lower than expected due to forecasting errors and other unanticipated effects. The effects to PBF 1 and 2 are minimized through the use of the central tendency and the UKL credit, which both provide mechanisms to maintain lake elevations when hydrology does not manifest as forecast.

In Unit 1, there is no causal link to adverse effects to water quality (PBF 1) in UKL from implementation of the proposed action; however, there is evidence that water diversions through the Project cause a net reduction in nutrients downstream of UKL, which is beneficial. 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. Under the proposed action there are expected to be occasional adverse effects to spawning and rearing habitat (PBF 2) and availability of preferred depths for adults (PBF 1), but they are expected to be rare enough that they will not limit the recovery function of UKL. The proposed Project does not affect food availability (PBF 3) in Unit 1.

In Unit 2, there is no effect to water quality (PBF 1) or food availability (PBF 3) from proposed Project operation in Clear Lake, but the effects of the proposed action on access to spawning habitat (PBF 1) are unclear. As described in the *Effects Analysis* (Section 7.4.1.1), there are no anticipated effects in wet or dry years, but there is uncertainty about whether adverse effects will occur under intermediate hydrologic conditions. Still, these effects are unlikely to impede the conservation role of critical habitat for the LRS and SNS in Clear Lake based on the recurring recruitment that has occurred in the recent past, which suggests that the habitat is available and does function when PBF 1 is present. The proposed action is likely to adversely affect rearing habitat (PBF 2) and adult habitat (PBF 1) during droughts that are likely to occur once during the term of this BiOp. In Gerber Reservoir, there are no adverse effects to PBFs of critical habitat as a result of the implementation of the proposed action. Project effects to PBF 1 and 2 in Gerber Reservoir are expected to be insignificant.

10.2.4 Summary of Cumulative Effects

In general, the cumulative effects on critical habitat described above are expected to improve the status in UKL through reductions in nutrient inputs and eventually in water quality (PBF 1), but the timeline for such improvements is uncertain.

10.2.5 Synopsis for Non-Adverse Modification Determination

Based on our analysis, designated critical habitat is expected to continue to provide the conservation role of critical habitat for LRS and SNS at the scale of designated critical habitat. Critical habitat range-wide remains functional in most years. To support LRS and SNS, which are long-lived, highly fecund species, critical habitat needs to support the survival of adults and recurrent, but not necessarily uninterrupted, reproduction because infrequent, strong cohorts can support populations. The adverse effects to the PBFs described above are temporary and do not preclude the critical habitat's support of adult survival and frequent successful reproduction and rearing. Therefore, we do not anticipate that effects of the proposed action, will result in the destruction or adverse modification of LRS and SNS critical habitat because 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 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 in USFWS regulations as an act that actually kills or injures fish or wildlife (50 CFR 222.102 and 50 CFR 17.3). Such an act may include 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). The USFWS regulatory definition of harassment is constrained to "intentional or negligent" activities and therefore not considered incidental take (50 CFR 17.3). 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, provided that such taking is in compliance with the terms and conditions of 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 USFWS as specified in the Incidental Take Statement [50 CFR 402.14(i)(3)].

11.1 Assumptions

In Sections 7.1 and 7.2 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 implementing 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 7.1) and *Key Assumptions for the Effects Analysis* (Section 7.2) within this BiOp for a description of the assumptions and sideboards upon which our analysis is based.

11.2 Amount or Extent of Take

Over the 5-year term of the proposed action, take of adults, juveniles, and larval LRS and/or SNS is anticipated to occur in the form of collect, capture, kill, and harm. USFWS anticipates the proposed action could result in the annual incidental take of up to 243,288 listed suckers by killing, 1,185,825 by injury, 36,000 by capture, and 100,000 by collection; approximately 99 percent of the anticipated annual incidental take would be of sucker larvae and eggs. Overall, the incidental take is expected to be both lethal and nonlethal and result from entrainment into Project facilities, seasonal habitat reductions in Project reservoirs due to water diversions, sucker monitoring and required studies, assisted rearing, and O&M activities associated with the Project, including sucker salvage (Table 11-1).

Table 11-1. 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	Kill and Injure	Larvae Juveniles Adults	1,160,904 larvae injured 210,372 larvae killed 24,821 juveniles injured 2,469 juveniles killed 2 adults killed
Stranding of Juveniles at Lake Elevations Lower than 4522 ft	Clear Lake	Kill	Juveniles	50 juveniles 5 adults
Dewatering of Spawning Habitat	Upper Klamath Lake	Kill	Eggs	14% reduction in the number of spawning females, 36% reduction in duration of spawning
Implementation of Conservation Measures	UKL and Tributaries Project canals	Kill and Collect	Eggs Larvae Juveniles Adults	30,000 eggs or larvae killed and 100,000 larvae collected; 240 juveniles killed and 1,500 collected; 1,000 adults captured and 100 killed
Monitoring of Adult Sucker Populations and Larval and Juvenile Entrainment[1]	UKL, Clear Lake, Gerber Reservoir, Tule Lake Sump 1A, and Keno Reservoir	Kill and Capture	Larvae Juveniles Adults	200 juveniles killed and 20,000 captured; 150 adults killed and 15,000 captured
Operation and Maintenance Activities	Project Wide	Kill Capture	All life stages	10 total of all life stages killed Capture and salvage of any suckers in the work area

1. Monitoring of adult sucker populations in Project reservoirs 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.

In most cases, the amount of incidental take of the listed suckers is based on limited data and numerous assumptions, and 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 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, 2000b). 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 estimate take as the maximum anticipated take so we would be less likely to underestimate the effect of the taking. We have also identified that the proposed action provides lake levels and flows that correlate with the amount of take described; these elements of the action are measurable and provide a suitable surrogate to identify when take may be exceeded.

11.2.1 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 6.5 and 7) 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 due to decreases in LRS and SNS population estimates based on the assumption that entrainment is likely to be proportional to the abundance of adult suckers. Additional assumptions for these entrainment estimates and the details of the calculations are described in Section 7.3.1.7.

11.2.2 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 130,000 larvae (20 percent of the 650,000 that reach the screen) pass through the screen and are entrained into the canal every year based on the maximum volume diverted in the model POR.

Most larvae that pass through the screen will be harmed because they are likely to be injured or die from adverse water quality conditions, passing through pumps and being discharged onto agricultural fields, or remaining in irrigation canals when they are drained at the end of the irrigation season. However, some larvae will survive in the canals and up to 1,500, with an average of around 300, 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; the amount will likely depend on several factors, including annual production, which can vary annually by several orders of magnitude (Simon et al. 2014). To ensure that we do not underestimate the take, we assume here that all larvae entrained into the A Canal will be killed. Thus, the maximum number of larvae killed by entrainment into the A Canal is expected to be 130,000 based on the calculations described in the *Effects Analysis*. Larvae that do not enter the A Canal are screened and diverted through the gravity bypass because the pumped bypass is not operated during the spring and early summer when larvae are present. We anticipate that the proportion of suckers injured or killed as a result of physical strikes with objects and pressure changes during gravity bypass would be less than or equal to the amount that passes through a dam, which is expected to be 2% (Whitney et al. 1997 pp. 16–17, Muir et al. 2001 p. 142). Thus, we expect an additional 10,400 larvae to be killed during bypass.

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 (Simon et al. 2014 pp. 79 & 101–102). Based on sampling at the FES between 2013 and 2018, the maximum expected number of juveniles bypassed would be 60,000 based on complete season estimates from 2016—the year with the highest catches at FES (USBR 2018b Appendix B). The pumped bypass has a "fish friendly" pump that minimizes injuries and mortality during bypass (Marine and Gorman 2005). Therefore, we expect that injuries and mortality would be less than that experienced during passage through a dam spillway and a maximum of 2% (1,200) could be killed due to physical strikes with objects or pressure changes (Whitney et al. 1997 pp. 16–17, Muir et al. 2001 p. 142). No adults should be entrained at the A Canal due to exclusion by the trash rack, which has 2 in (5 cm) openings. All of the suckers passing through the pumped or gravity bypass will be experience substantial disruption of normal behaviors, such as feeding and predator avoidance. However, as described above we expect 2% could be injured or killed. Thus, we estimate that up to 1,200 juveniles could be killed annually at the A Canal.

11.2.2.1 *Link River Dam Entrainment Estimates*

Based on the analysis described in the *Effects Analysis* section, 2.37 million total suckers could be entrained annually at Link River Dam. Because power generation has ceased at both the West Side and the East Side Power Canal, nearly all of the Link River flow passes through the spillway gates of the dam, and consequently we assumed all of the take occurring there will be attributable to the Project. 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, we assumed that 2% of the fish passing through the spillway of the Link River Dam will be harmed (Whitney et al. 1997 pp. 16–17, Muir et al. 2001 p. 142).

Based on the period of record, the maximum annual larval entrainment is expected to be 2,333,460 with harm to 46,669 of those. We estimate that up to 3,227 age-0 juveniles could be entrained at the dam every year based on observed densities of entrained juveniles prior to the installation of the fish screen at the A Canal. We estimate that an additional 28,400 age-0 juveniles could be entrained at the Link River Dam after passing through the pumped bypass (50% of bypassed individuals, see *Effects Analysis*). We assume that 2% of the juveniles entrained (31,627) through Link River Dam are likely harmed by passing through the spillway gates as described above, resulting in an estimate of 633 harmed juveniles. Similarly, annual entrainment of adult suckers at the Link River Dam is estimated to be approximately 57 plus an additional 54 bypassed from the A Canal. Assuming that 2% of these 111 adults are killed as a result of physical strikes with objects and pressure changes associated with passing through the spill gates, the number of adults killed would be 2.

We estimate that up to 2.33 million larvae, 31,627 juveniles, and 111 adults could be entrained annually; of the suckers entrained, the maximum annual lethal take at the Link River Dam is estimated to be 46,669 larvae, 633 juveniles, and 2 adults.

11.2.2.2 *Entrainment at Clear Lake Dam*

In contrast to Upper Klamath Lake, there is no upstream passage for fish that are entrained through Clear Lake Dam. There is no accessible spawning habitat in the Lost River system below Clear Lake Dam or Gerber Reservoir Dam, so even if individuals survive the relatively poor habitat conditions in the Lost River, entrained individuals are effectively lost from the reproducing populations. Therefore, we have treated all entrainment through Clear Lake Dam as take, which could manifest in the form of harm as individuals pass through the dam or as an inability for individuals to reproduce.

Releases from Clear Lake Dam were sampled for larval and juvenile fish between April 22, 2013, to July 17, 2013, and an estimated 268,335 larval suckers and 3,659 juvenile suckers were entrained over that period. Larval sucker entrainment was concentrated in the spring with the bulk of the catch coming between the last week of April and mid-May, but some larval entrainment was observed into June. The timing of larval drift is likely to vary among years. Based on the timing of adult migration relative to the run in 2013 (Hewitt and Hayes 2013, D. Hewitt personal communication), we infer that the larval entrainment period most likely falls between April 1 and June 30 in all years. Because we do not have information on the interannual variation in larval abundance, we assumed that 2013 was representative of larval densities in Clear Lake. Thus, we multiplied average larval densities between April 22 and June 30, 2013 (22.3027 larvae/AF), by the volume of water released from Clear Lake between in April-June for each water year between 1986 and 2018 to estimate larval entrainment. During times of extremely high inflows, Reclamation makes flood control releases to ensure that sufficient capacity remains in the reservoir. Entrainment under such conditions would not be considered take because it is driven by hydrology rather than water management and such operations are outside of Reclamation's discretion. Excluding years with flood control operations (1998 and 1999) and 2000 due to releases in preparation for dam reconstruction, the maximum estimated entrainment of larvae was 573,654 individuals. We anticipate that 2% of these (11,473) are likely to be killed as they pass through the dam as described above. The remaining 562,181 individuals would not be able to complete their life cycle as described above, which we consider to be injury.

Juvenile sucker entrainment was estimated in a similar manner except there was no clear seasonal pattern in juvenile sucker entrainment during the 2013 study, so we assume that juvenile entrainment is constant across the year. Thus, the average density of juvenile suckers from the 2013 study (0.1867 juveniles/AF) was multiplied by the total releases for the water year, and the maximum that occurred between 1986 and 2018 was 12,265. As described above, 2% (245) are expected to be killed, and the rest (12,020) are expected to be injured. We do not anticipate take of any adults through entrainment at Clear Lake Dam.

11.2.2.3 *Entrainment at Gerber Reservoir Dam*

Although data on the densities of entrained suckers at Gerber Reservoir Dam are not available, salvage efforts and sampling in Miller Creek indicate that some suckers are entrained annually (Hamilton et al. 2003). We expect larval entrainment to be less than or equal to the entrainment at Clear Lake Dam for two reasons: 1) the adult SNS population in Gerber Reservoir is thought to be smaller than the combined SNS and LRS populations in Clear Lake, so we expect that larval and juvenile production is also smaller and 2) larvae in Clear Lake are likely to be more vulnerable to entrainment than those in Gerber Reservoir due to the proximity of the mouth of Willow Creek to Clear Lake Dam. Therefore, we anticipate that the maximum annual entrainment at Gerber Reservoir would not be greater than the entrainment estimated at Clear Lake.

11.2.2.4 *Entrainment at Other Project Facilities*

Entrainment is also likely occurring at other Project facilities, such as Lost River Diversion Channel and diversions along the Lost River, including privately owned diversions that use Project water, as discussed in the *Effects of the Action* (section 8), but we lack the location-specific data to precisely estimate take at these facilities. Take at most of these locations, particularly the private diversions along the canal system and the Lost River, would comprise individuals that are included in the estimates of take through entrainment at other facilities such as Clear Lake Dam, Gerber Reservoir Dam, and the A Canal. We have used the best available information to account for take through these locations regardless of previous entrainment into canals or other structures.

Entrainment at the locations described above is difficult to quantify but is likely occur at a low level because of the smaller volumes of water moving through these structures and the low density of suckers in these areas. There is extremely limited data available on sucker densities outside of the main reservoirs. The available information includes sampling in the Lost River system, which yielded 6.5% of mean catches from sampling in Clear Lake (Shively et al. 2000 p. 82, Hewitt and Hayes 2013 p. 17). Therefore, we assume that collectively, Project facilities that are not discussed in the above sections, including private diversions that use Project water, are likely to have approximately 6.5% of entrainment that occurs from Clear Lake (Table 11-2).

11.2.2.5 *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 212,845 killed and 1.19 million injured; most of these will be larvae (Table 11-2).

Table 11-2. Estimated annual maximum take due to entrainment of LRS and SNS at Project facilities as a result of implementing the proposed action.

Location	Larvae		Juveniles		Adults	
	Non-Lethal	Lethal	Non-Lethal	Lethal	Non-Lethal	Lethal
A Canal	0	140,011	0	1,200	0	0
Link River Dam	0	46,669	0	763	0	2
Clear Lake Dam	562,181	11,473	12,020	245	0	0
Gerber Reservoir Dam	562,181	11,473	12,020	245	0	0
Other Project Facilities	36,542	746	781	16	0	0
Total	1,160,904	210,372	24,821	2,469	0	2

11.2.2.6 *Seasonal Reductions in Habitat due to Water Management and Reduced Instream Flows*

The proposed action could result in take of individuals at the springs along the eastern shoreline of UKL under certain conditions. Elevations that fall below 4,142 ft (1,262.5 m) between the end of March and the end of May would be expected to alter the spawning behavior of LRS at the shoreline springs. At elevations between 4141.4 ft (1,262.3 m) and 4142 ft (1,262.5 m), we would expect reduced spawning durations for female suckers by approximately 20% (Burdick et al. 2015b p. 487). If we assume that spawning duration is directly proportional to eggs deposited, these elevations would result in take of approximately 20% of the reproductive output of the shoreline springs spawning population. More extreme elevations, similar to those observed in 2010, would be expected to result in 14% fewer females spawning and a 36% reduction in duration on the spawning grounds (Burdick et al. 2015b pp. 483–484). In only one year in the model POR did elevations resemble those observed in 2010, so similar reductions in spawning would be expected to be the maximum observed in a given year. However, the frequency of adverse effects is also a concern. Based on the period of record, we do not expect that elevations below 4,142 ft (1,262.5 m) during the spawning season would occur in consecutive years or in more than 2 years during the term of this BiOp. Therefore, lake elevations below 4,142 ft (1,262.5 m) between the end of March and the end of May in consecutive years or in more than 2 years during the implementation of the proposed action would fall outside the scope of this BiOp, as described in Section 7.2, and therefore this incidental take statement.

As described in the *Effects Analysis*, the dewatering of wetlands under the proposed action could displace larvae. Larvae tend to occur in higher densities in emergent wetland habitats. Higher densities of larvae in emergent wetlands could result from active selection of the habitat, reduced movement out of the habitat, or increased survival within the habitat. Habitat selection or decreased movement likely would be driven by access to some resource, such as food or cover. Thus, displacement from the habitat would likely result in decreased access to this resource or in decreased survival. However, the specific effects of decreased wetland inundation on survival is difficult to infer, particularly given that lake elevations would be expected to decrease from spring to fall due to natural hydrology. One way to evaluate the sufficiency of wetland inundation is to compare lake elevations from the model POR on July 15, after which emergent wetlands are thought to be less important, with conditions observed before the construction of Link River Dam. Only one model year (1992) is below the range for observed pre-dam conditions (minimum of 4,140.0 ft or 1,261.9 m), and 33 of 36 model years are above the mean from the pre-dam period. Based on this comparison, we anticipate that there could be take of larval suckers by increasing mortality rates when lake elevations fall below 4,140.0 ft (1,261.9 m), at which 11% of wetland edge habitat is inundated to at least 1 ft (0.3 m). The lowest elevation in the model POR on July 15 was 4,139.79 ft (1,261.8 m), at which 10% of wetland edge habitat is inundated to at least 1 ft (0.3 m). However, this is very unlikely to occur during the 5-year term of this BiOp. Thus, we do not anticipate take of larvae through dewatering of wetlands when elevations are greater than or equal to 4,140.0 ft (1,269.9 m) on July 15, and we do not anticipate this occurring during the term of this BiOp. Lake elevations lower than 4,140.0 ft (1,261.9 m) on July 15 would therefore result in more take than analyzed in this BiOp.

In Clear Lake there is an increased risk of stranding of juvenile suckers during droughts. For example, the pool of water near Clear Lake Dam became disconnected from the east lobe in 2009 when lake elevations were around 4522 ft (1375.3 m). Based on salvage efforts during that event, we anticipate that elevations below 4,522 ft (1,375.3 m) could kill approximately 50 juvenile and 5 adult suckers due to stranding. In addition, there is uncertainty about the potential for take when access to Willow Creek for spawning is limited at certain lake levels, if and when those conditions are attributable to water management.

Other effects to habitat such as depths at the entrance to Pelican Bay, availability of preferred depths in UKL, and changes in depth at the shoreline springs during egg incubation are not expected to result in take based on the period of record. However, these effects could result in take if conditions fall outside those expected under the proposed action (see Section 7.2).

11.2.2.7 *Incidental Take Caused by LRS and SNS Monitoring Activities in Project Reservoirs*

Reclamation is required to implement monitoring of adult suckers in Project reservoirs as part of their incidental take monitoring requirements described below. As a result of this monitoring, LRS and SNS will be captured and a small percentage harmed, both of which are considered take under the ESA. Assuming the required adult monitoring would occur at the five large reservoirs used by the Project (UKL, Clear Lake, Gerber Reservoir, Tule Lake Sump 1A, Keno Reservoir) in any given year, we estimate the maximum annual take by capture for adult suckers from monitoring would be approximately 15,000 total, most of which are likely to be SNS because they dominate in all of the reservoirs except UKL. In developing these estimates, we assumed maximum capture rates based on previous studies done in these reservoirs (Hewitt and Hayes 2013, Hewitt et al. 2018). Capture is likely to alter normal behavior substantially, such as feeding and predator avoidance, at least for a short time. Mortality as a result of monitoring activities is estimated to be very low (E. Janney, Personal Communication, February 8, 2019). To ensure that we do not underestimate the impacts of these activities we assume 1% (i.e., 150 total LRS and SNS) will be harmed by unavoidable injuries received during capture. Because this take of adults is spread among the major sucker populations, adverse effects are not likely to be concentrated at any one location.

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 not all of the monitoring is likely to be done in a given year due to staffing and funding limitations and we have not required all of the monitoring to be done every year.

Reclamation is also required to monitor take of age-0 suckers at the 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 et al. 2010). Based on the captures at the FES between 2013 and 2018 (USBR 2018b), 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; additional fish arrive moribund and die but not due to collection and handling. Capture is likely to disrupt normal behaviors, such as feeding and predator avoidance, for all of these individuals.

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 although some individuals are harmed, most of the suckers handled will only have a temporary disruption to their normal behavior. In summary, we estimated up to 200 juveniles and 150 adult suckers could be killed annually as a result of monitoring at the FES and in Project reservoirs.

11.2.2.8 *Incidental Take Caused by Proposed Conservation Measures*

11.2.2.8.1 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. All of these individuals will experience substantial disruption of normal behaviors, and we assume based on recent relocation efforts that 5% (i.e., 75 total LRS and SNS) will be killed during capture and transport (Zachary Tiemann, USFWS, personal communication December 20, 2018). Although we expect survival to be higher for fish that are salvaged and rehabilitated at the assisted rearing facility, additional mortality is expected during captivity due to preexisting afflictions. Based on recent rehabilitation efforts, we anticipate that 11% (165) could die prior to release into UKL.

11.2.2.8.2 Tule Lake Sump 1A Contingency Relocation

There is the small potential for an adverse impact to suckers in Tule Lake Sump 1A if a relocation operation is required. In the unlikely event that a relocation effort is needed at the Tule Lake sumps, this action will result in an adverse impact to suckers through the capture of up to 1,000 individuals and the mortality of up to 100 individuals during capture, transport, and release.

11.2.2.8.3 Assisted Rearing

Reclamation proposes to fund a USFWS-implemented assisted rearing program for the LRS and SNS. To implement the rearing program, we anticipate that up to 100,000 larvae will be removed from the wild each year. If larval collections do not yield the numbers required to meet production targets, up to 100,000 eggs could be collected. In most years, collections will be much smaller—for example we anticipate collection of 20,000 larvae in 2019—and the full number of larvae and eggs would not be collected in the same year, but we expect that rearing capacity could increase over the term of the BiOp to accommodate 100,000 individuals per year. The source of the eggs or larvae will be the Williamson River and the lakeshore springs. Based on recent survival rates at the assisted rearing facility, we estimate that 30% (30,000) of the larvae could die at some point when they are in captivity. However, the mortality rate is expected to be much lower than that of larvae that are not brought into captivity.

11.2.2.8.4 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.

11.2.2.9 *Incidental Take Caused by O & M Activities*

Reclamation intends to perform various annual maintenance activities that could require sucker salvage. Based on similar efforts in the past, this could result in killing up to 10 total suckers of all life stages. Because capture of suckers during salvage efforts is anticipated to be a beneficial action, this ITS authorizes the capture of all suckers in the immediate project area for the purpose of salvage to minimize harm.

11.2.3 Incidental Take Summary

In summary, we anticipate that the proposed action could result in annual take of all types of up to 1,565,675 LRS and SNS of all life stages and lethal take of up to 243,450 individuals (Table 14.3). The vast majority of the take (99%) will be larvae. Entrainment is the largest single action resulting in take.

Table 11-3. Summary of anticipated maximum annual amount of incidental take occurring as a result of the proposed action.

Form of Take	Eggs or Larvae	Larvae	Juveniles	Adults	Unspecific Life Stage	Totals
Kill	30,000	210,372	2,909	259	10	243,450
Injure	0	1,160,904	24,821	0	0	1,185,725
Capture	0	0	20,000	16,000	0*	35,000
Collection	100,000	0	1,500	0	0	101,500

*Capture and salvage of all suckers in the vicinity of O&M activities is authorized.

11.3 Effect of the Take

In the accompanying biological opinion, USFWS determined that this level of anticipated take is not likely to result in jeopardy to LRS and SNS.

11.3.1 Reasonable and Prudent Measures (RPM)

USFWS believes that the following reasonable and prudent measures and Terms and Conditions are necessary and appropriate to minimize the impacts of incidental take of LRS and SNS 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.

11.3.2 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 and the following Terms and Conditions that implement the reasonable and prudent measure described above. These Terms and Conditions are nondiscretionary.

T&C 1a. Ensure that No Unnecessary Actions are Taken that Increase Entrainment 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 11.4, *Entrainment Monitoring at Project Facilities*.

T&C 1b. Actions to Determine Irrigation Supply and Take Corrective Actions to Avoid Going below Minimum Elevations in Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A

Prior to initiation of deliveries to irrigators or prior to April 15, whichever comes first, of each year, Reclamation shall assess projected inflows and water levels in Clear Lake and Gerber Reservoirs to determine an anticipated irrigation supply from each reservoir along with projected end of season lake elevations. Reclamation shall coordinate with the USFWS to ensure the anticipated irrigation supply falls within the effects analyzed and incidental take authorized in this BiOp. This coordination is to ensure that releases, particularly those above and beyond typical historical releases, will not result in increased harm to listed suckers in Clear Lake Reservoir due to reduced access to spawning habitat in Willow Creek. Projected end of September targets shall be at or above minimum elevations.

Irrigation releases from Clear Lake Reservoir greater than the typical historical demand could result in Clear Lake Reservoir elevations that are consistently lower than those analyzed in this document, which in turn may reduce the likelihood of adequate lake elevations to allow access to spawning habitat in Willow Creek (see Section 7.4.1). Therefore, USFWS expects that deliveries from Clear Lake Reservoir will be similar to those typical across the 1986 through 2016 period, exclusive of atypical conditions (i.e., flood control releases, other releases for public health and safety, inadequate water supply, etc.). Typical total annual irrigation releases across the 1986 through 2016 period were as high as 40,376 AF, and the proposed action indicates that Reclamation expects typical annual irrigation releases to be approximately 35,000 AF.

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 Reservoir, 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 to determine the most appropriate action to minimize risk to affected listed species. Reclamation's required water-level monitoring for Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A is described below under section 11.4.

T&C 1c. Take Corrective Actions to Ensure UKL Elevations Are Managed within the Scope of the Proposed Action

The bounds to the hydrological conditions expected under this BiOp are described in the *Effects of the Action* (section 8). Conditions outside these bounds may result in greater adverse effects than analyzed in this BiOp and exceedance of the take anticipated in the *Incidental Take Statement*. Based on the POR, these conditions are extremely unlikely to occur during the term of this BiOp. As the irrigation season progresses from March 1 – September 30, Reclamation shall monitor UKL elevations to determine if there is a projected or realized progressive decrease in the elevation that would fall outside of the boundary conditions for the effects analysis (as described in Section 7.1):

- 2 consecutive years in which UKL surface elevations fall below 4142 in April or May
- UKL surface elevations below observed elevations in 2010 in April or May
- UKL surface elevations below 4138.26 ft (1,261.36 m) at any time
- More than one water year when UKL surface elevations drop below 4,138.5 ft (1,261.4 m) in September
- Any year with UKL surface elevations less than 4,140.0 ft (1,261.9 m) by July 15, more than 1 year when surface elevations fall below 4140.5 ft (1,262.0 m) by July 15, or more than 2 years when surface elevations fall below 4140.8 ft (1,261.1 m) by July 15

If a progressive decrease in elevations that is projected to fall outside the conditions outlined above 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. Reclamation shall immediately consult with USFWS concerning the causes 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 consult 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 but can appear as early as mid-July.

T&C 1e. Develop and Implement a Hydrological and Biological Data Management Plan

Effective management of hydrological and biological data is essential to ensure that take and other Project effects can be evaluated and to maintain a period of record for future consultations. Therefore, Reclamation shall develop a data management plan that will include the details of how data will be stored and shared with USFWS and other agencies. Reclamation shall develop the plan in coordination with USFWS, providing a draft plan by October 1, 2019, and a final plan by December 1, 2019; these dates can be adjusted to ensure a high-quality product if both Reclamation and USFWS agree that it is necessary.

The plan shall include standard operating procedures for collecting, reviewing, finalizing, storing, and presenting Project reservoir elevation, flow, diversion, and pumping data as well as biological data collected during salvage, FES monitoring, and Gerber Reservoir monitoring. The plan shall include annual updates to hydrological data sets, including those described in Section 7.1, as well as plans for finalizing historical data sets such that official versions are available upon request or via web hosting. The plan shall also include an annual update of the KBPM, with output provided to the Service.

T&C 1f. Annual Identification and Installation of Needed Water-Level and Flow-Measurement Gages in the Project

Reclamation shall consult with Service hydrologists, biologists, and other appropriate agencies (e.g., USGS, Oregon Department of Water Resources, PacifiCorp, and irrigation districts) to assess the need for additional or replacement gages in the Project area, at least annually, beginning July 1, 2019. If additional 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 necessary gages shall be included in the *Annual Monitoring Report* due every March 1.

T&C 1g. Monitor Keno Impoundment and UKL Project-Related Diversions

Reclamation shall monitor Project-related diversions in the Keno Impoundment and around UKL to reduce uncertainty associated with the unknown volumes of water delivered to these lands under operation of the Klamath Project. Monitoring and annual reporting of these Project-related diversions helps ensure that the diversion volumes are consistent with what was modeled in the KBPM for the POR and will provide NMFS with more certainty regarding KBPM output, specifically IGD flows, Project deliveries and UKL elevations. More certainty in water allocations will help improve the KBPM and reduce error through time and aid in in-season management to address disease issues and minimize incidental take. Reclamation shall also compile monitoring data for these diversions on an annual basis for the duration of the proposed action and assemble the data into a complete data set to be reported in the Annual Monitoring Report and incorporated into the next proposed action.

T&C 1h. Operations Updates

As of early February 2019, 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 4 of Reclamation's biological assessment (USBR 2018a Appendix 4) into an operations spreadsheet(s). The operations spreadsheet(s) will bring together the input data (e.g., UKL net inflow, UKL elevations, NRCS forecasts), equations (e.g., seasonal water supply allocations, daily EWA releases), 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, 2019, and at least annually thereafter. Reclamation shall provide updates to the Service within 2 weeks of Reclamation's acceptance and use of an updated operations spreadsheet(s). Reclamation shall provide the Services with a tutorial explaining how Reclamation uses the spreadsheet, which data may be updated, and which data should remain fixed and not be changed or updated. This tutorial will be offered, as Reclamation operations' staff are available, to new Service employees with relevant designations (e.g., hydrologist) as they join Services' staff throughout the life of this BiOp.

T&C 1i. Consultation with the Services on Release of Project Call Water

Reclamation has proposed to quantify an amount of inflow that may result from a Project call and deliver this amount to Project irrigators as that additional inflow manifests during the irrigation season. Ultimately, a scientifically robust, peer-reviewed methodology should be developed and used to quantify call water, but none is available at this time. A protracted period without an agreed-upon method for call water quantification may result in unforeseen consequences for listed species, including the potential for increased take beyond that contemplated in the Services' BiOps. Therefore, Reclamation shall produce a robust water quantification tool or method by June 1, 2021. Reclamation shall have the tool or method peer-reviewed and make any necessary adjustments identified by this process by June 1, 2022. During the interim period, while development of this tool or method is ongoing (i.e., water years 2019 and 2020) and prior to a call being made, Reclamation shall coordinate with the Services to quantify any additional volume of water related to a Project call and determine potential impacts of its delivery to listed species before delivery quantity is announced or deliveries begin. This coordination will ensure that call water quantification methodology is sound and does not result in the potential for take of species greater than that which was analyzed by the Services in their BiOps.

Reclamation shall coordinate with the Services, and other appropriate agencies (e.g., USGS, Oregon Water Resources Department, irrigation districts), for review and technical support in the development of the quantification tool or method. Reclamation will also coordinate with the Services in planning and conducting peer review.

T&C 1j. Ensure Project Impacts on Spawning Access in Clear Lake are not Greater Than Anticipated

Uncertainty remains about the effects of Project implementation access to Willow Creek, which contains the only known spawning habitat for SNS and LRS in Clear Lake Reservoir. New information on the streamflow conditions that provide for spawning access is anticipated to be available within the next year. Take of listed suckers in Clear Lake Reservoir may be greater than analyzed in light of the anticipated new data. Therefore, when that information is available, Reclamation shall coordinate with the Service to perform an analysis synthesizing the hydrologic conditions necessary for sucker spawning to determine whether there is a set of conditions under which the Project operations limit access to spawning habitat. This analysis shall be completed by March 1, 2020, providing that the new information on Project impacts to Clear Lake Reservoir spawning habitat access is available prior to this date with reasonable time to conduct the analysis. If the information is not available to meet the above conditions, the analysis shall be performed as soon as possible thereafter but no later than a date identified and agreeable to the Service and Reclamation.

Terms and Conditions Implementation Agreement

Reclamation shall develop an *"Implementation Plan*" in consultation with the Services describing how Reclamation intends to implement the Terms and Conditions in this opinion. The *Implementation Plan* 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. Having this agreement will ensure that terms and conditions are reliably and fully implemented and will aid in identifying any problems as early as possible and help avoid any additional incidental take of listed species above those considered in this opinion.

We understand that this Opinion 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. Reclamation shall develop the draft *Implementation Plan* in consultation with the Services, provide the Services a draft *Implementation Plan* for review and comment by October 1, 2019, provide the Services a final *Implementation Plan* that addresses the Services' comments by December 15, 2019, and implement the final *Implementation Plan* thereafter; these dates can be adjusted to ensure a high quality product if Reclamation, NMFS and USFWS agree that it is necessary.

11.4 Mandatory Monitoring and Reporting Requirements under the Terms and Conditions

11.4.1 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 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 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 July 15 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 approximately July 15 of every year with sampling on one night per week until at least 10 juvenile suckers are captured in a night or August 1, whichever comes first, after which sampling will continue four nights per week until no additional suckers are collected in the FES in a given week, September 30, or a date agreeable to the USFWS. Reclamation will sample consistent with recent FES sampling to ensure comparisons can be made among years.

Samples need to be taken at night because that is when most sucker movement occurs. All suckers in FES samples will be counted, 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 Friday. 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.

1b. Flow Monitoring at the A Canal, and Link River, Clear Lake Reservoir, 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 Reservoir, 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 reservoirs, 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. 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, 2000b). The studies that Gutermuth et al. (2000a, 2000b) 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 likely 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.

1c. Canal Salvage Reporting

Reclamation has proposed to salvage suckers entrained into the irrigation canal system during drawdown in the fall. Salvage efforts include take of individuals through capture, and the results of this salvage effort will be included in the *Annual Monitoring Report*.

2. Adult LRS and SNS Monitoring in Project Reservoirs

The USFWS anticipates that the monitoring efforts in the proposed action (Section 4.5.3) 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 UKL and Clear Lake is necessary. However, the status of populations and the extent of Project effects in Gerber Reservoir are less certain. Therefore, Reclamation shall undertake annual trammel net sampling in Gerber Reservoir to monitor the population, including gather size-frequency data, implant PIT tags, and scan fish for previously implanted tags. The results of this effort will be included in the *Annual Monitoring Report*. The sampling efforts will be coordinated with USFWS and adjusted as necessary to maximize the value of the monitoring.

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 for the annual updates during the duration of this Biological Opinion, instead of WRIMS 1.0. Reclamation may update the software to new versions as they are published and verified, and Reclamation shall inform the Services prior to doing so. The potential use of software other than WRIMS will be evaluated in coordination with the Services.

3b. 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 *Hydrological and Biological Data Management Plan* developed under T&C 1e. 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.

Accurate hydrologic data are needed to calculate Project water use and effects on listed suckers and ensure compliance with this Incidental Take Statement. Monitoring shall be conducted at the following, and the list shall be evaluated annually and could include additional monitoring if needed.

1. A Canal
2. Lost River to Lost River Diversion Channel at Lost River Diversion
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 at Link River Dam
7. Station 48
8. Miller Hill Pumping Plant
9. Miller Hill spill
10. UKL, Clear Lake, Gerber Reservoir, and Tule Lake Sump 1A
11. Link River Dam
12. Keno Dam
13. Iron Gate Dam
14. Reductions to IGD flow due to UKL control logic
15. EWA spending
16. Ungaged Project diversion in Keno Impoundment and around UKL

11.5 Terms and Conditions and Monitoring Summary

A table summarizing the LRS and SNS Terms and Conditions and monitoring activities with deadlines and implementation schedule is shown below in Table 11-4.

Table 11-4. Summary of LRS and SNS Terms and Conditions and monitoring with specific deadlines. Items not included here will be implemented as necessary or in coordination with USFWS.

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
T&C 1a	Ensure that No Unnecessary Actions are Taken that Increase Entrainment at the Link River Dam	Typically, August – Early September	N/A	Annually	N/A	N/A	Reclamation to monitor numbers of age-0 juvenile and older suckers moving through FES to determine peak entrainment.
T&C 1b	Actions to Determine Irrigation Supply and Take Corrective Actions to Avoid Going below Minimum Elevations in Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A	April 15 or before irrigation begins	N/A	Weekly	N/A	N/A	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 1c	Take Corrective Actions to Ensure UKL Elevations are Managed within the Scope of the Proposed Action	March 1	September 30	Annually	N/A	N/A	If a progressive decline in UKL elevations becomes evident to Reclamation or USFWS, immediate consultation between the agencies on corrective action is required.

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
T&C 1d	Activate the A Canal Pumped-bypass System Annually by August 1	**Begin Consult:** July 1 **Activate Pumped-bypass no later than:** August 1	N/A	Weekly	N/A	N/A	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	Develop and Implement a Hydrologic Data Management Plan	N/A	N/A	Annually	October 1, 2019	December 1, 2019	Begin implementation January 1, 2020
T&C 1f	Annual Identification and Installation of Needed Water-Level and Flow-Measurement Gages in the Project	July 1, 2019	N/A	Annually	N/A	N/A	Annual summary in *Annual Monitoring Report* by March 1
T&C 1g	Monitor Keno Impoundment and UKL Project-Related Diversions	N/A	N/A	Annually	N/A	N/A	Annual Summary in *Annual Monitoring Report* by March 1
T&C 1h	Operation Updates	June 1, 2019	N/A	Biweekly	N/A	N/A	Creation and dissemination of operations spreadsheet(s)
T&C 1i	Consultation with the Services on Release of Project Call Water	Prior to Project call	N/A	Annually	June 1, 2021	June 1, 2022	Annual consultation with the Services while call quantification tool is developed.
T&C 1j	Ensure Project Impacts on Spawning access in Clear	N/A	N/A	N/A	N/A	March 1, 2020	Utilize streamflow dataset and Clear Lake elevation to

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
	Lake are not Greater than Anticipated						analyze access to spawning habitat and potential Project delivery-caused limitation to access
Mandatory Monitoring 1a	A Canal Fish Evaluation Station Entrainment Monitoring	July 15	September 30	Annually	N/A	N/A	End date can be moved to a date agreeable to USFWS
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 April 15, 2019 Clear Lake and Gerber Dam monitoring may end as early as June 1
Mandatory Monitoring 1c	Canal Salvage Reporting	N/A	N/A	Annually	N/A	N/A	Annual Summary in *Annual Monitoring Report* by March 1
Mandatory Monitoring 2	Adult LRS and SNS Monitoring in Project Reservoirs	N/A	N/A	Annually	N/A	N/A	Expected to include annual trammel netting to capture and tag adult suckers. Coordinate with USFWS to determine additional PIT-array and other monitoring needs. Annual Summary in *Annual Monitoring Report* by March 1
Mandatory Monitoring 3a	Klamath Basin Planning Model	N/A	N/A	At least Annually	N/A	N/A	Klamath Basin Planning Model updated annually, using the WRIMS 2.0 software platform.

T&C or Mandatory Monitoring	Title of Requirement	Start Date	End Date	Interval	Draft Plan Due Date	Final Plan Due Date	Notes
							New software may be used in coordination with the Services.
Mandatory Monitoring 3b	Monitor and Maintain Water-Level and Flow-Measurement Gages throughout the Project	N/A	N/A	Daily	N/A	N/A	**Begin upon receipt of BiOp**. Sixteen locations require accurate data and those locations should be evaluated annually for accuracy.

11.6 Reporting Requirements

As part of meeting the reporting requirements of this Incidental Take Statement, Reclamation shall provide the Service with an *Annual Monitoring Report* due March 1 every year and organize annual 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* by October 1, 2019 that will be effective and efficient. Continued use of the format developed under the 2013 BiOp is acceptable, though USFWS may request changes as needs are identified. The first *Annual Monitoring Report* shall be due March 1, 2020.

In the first quarter of each year, Reclamation shall convene annual ESA compliance meetings with USFWS and NMFS to describe and discuss BiOp compliance, incidental take monitoring, and progress on implementation of the Terms and Conditions and Conservation Measures. A summary of necessary communications is found below in Table 11-5. A summary of coordination meetings related to Term and Conditions monitoring requirements is found below in Table 11-6.

Table 11-5. 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 11.6 Reporting Requirements	(1) Progress on implementation of T&Cs; (2) Progress on budgeting for implementation of T&Cs; (3) Progress on implementation of Conservation Measures	March 1	Develop acceptable format in coordination with USFWS no later than October 1, 2019 First report due **March 1, 2020**.
	Monitoring and Reporting Requirement 1b	Flow data reported as acre-feet per day through A-Canal, Link River Dam, Clear Lake Dam, and Gerber Reservoir Dam		Included in body of annual monitoring report. Additional technical requirements included in text.
	Monitoring and Reporting Requirement 2	Adult LRS and SNS monitoring at UKL, Clear Lake, and Gerber Reservoir		Included in body of annual monitoring report. Additional technical requirements included in text.
	Monitoring and Reporting Requirement 3b	(1) Summary of reservoir water level and flow monitoring compliance; (2) Summary of progress on identification and installation of needed gages		Included in body of annual monitoring report. Additional technical requirements included in text.

Table 11-5 Continued.

Title of Requirement	Requirement Reference	Required Components	Due Date	Notes
A Canal FES Monitoring Annual Report	Monitoring and Reporting Requirement 1a	Methods, results, and recommendations to improve monitoring	March 1	Included as an appendix to the annual monitoring report
Annual Salvage Report	Monitoring and Reporting Requirement 1c	Methods and results of annual canal salvage efforts	March 1	Included as an appendix to the annual monitoring report
Term and Condition Implementation Plan	N/A	Describe process to ensure compliance with T&Cs and complete monitoring and reporting by due dates	December 15, 2019	Develop in coordination with the Services. First draft due by **October 1, 2019**. Date of final submission can be at a date agreeable to the Services.

Table 11-6 Summary of recurrent meetings required to implement Term and Conditions, monitor incidental take, and meet associated reporting requirements.

Meeting Title	Requirement Reference	Required Components	Due Date
Annual ESA Compliance Meeting	Section 11.6 Reporting Requirements	Describe and discuss BiOp compliance, incidental take monitoring, and progress on implementation of the T&Cs and conservation measures	By March 31
Determine Clear Lake and Gerber Reservoir Allocations	T&C 1b	(1) Ensure end of season targets are above proposed minimums (2) Ensure deliveries are in line with the proposed action in coordination with USFWS	Prior to irrigation delivery or April 15, whichever comes first

11.6.1 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 1 every year through March 2024.

12 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 Service makes the following recommendations:

1. Reclamation should continue to support discussions and activities that lead toward Basin-wide solutions for issues that have been raised for threatened and endangered species, National Wildlife Refuges, agriculture, fishing, power production and other interests of tribes, private individuals, non-governmental organizations, commercial interests, and various agencies. By understanding and addressing these issues holistically, new solutions seem likely to be found that will be beneficial to multiple parties that allow for additional progress, including movement toward recovery of suckers.

2. Reclamation should provide support toward addressing water quality issues in Upper Klamath Lake, including funding for water quality monitoring that maintains long-term data sets and helping address poor water quality. Although the relationship between lake levels and water quality needs additional research, Reclamation's support could still help movement toward recovery of suckers. As an example, USGS has collected high temporal resolution water quality data on UKL for over 15 years that could provide a robust evaluation of any link between lake elevations and water quality. Reclamation, in coordination with USFWS and other parties as necessary, could determine whether these data display a connection between UKL elevations and water quality.

3. Support formation of a technical team with experts from various stakeholder groups that can meet regularly to generate ideas that can be used for adaptive management needs and development of future proposed actions, including, for example, the possibility of adjusting water operations to maximize available habitat when spring temperatures, which can lead to better summer water quality. This team should include individuals with hydrologic and biologic expertise and who represent Federal agencies, tribes, water users, and other appropriate stakeholders who are able to provide constructive ideas for management of water, wildlife and other resources.

13 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. Because the proposed action is an annual operation, the status of the species could change across the term of the BiOp. If the status of the species changes to an extent that the anticipated take from this action would have greater population level effects than analyzed in this BiOp, reinitiation of formal consultation would be required.

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APPENDIX A. INCIDENTAL TAKE CALCULATIONS USING DATA FROM THE FISH EVALUATION STATION

To estimate the incidental take of endangered Lost River and shortnose suckers at the A Canal from the proposed action, we devised a simple model that describes capture data from the Reclamation's Fish Evaluation Station (FES). Reclamation sampled for suckers in a standardized way at this facility between 2013 and 2018. The sampling consisted of six replicate samples, each 30 minutes in duration, beginning at 8:00 p.m. and lasting until 2:00 a.m. the following morning. This was done four nights a week throughout the month of August with some periodic sampling beginning mid-July and extending to mid-September, if densities were high enough to warrant the effort. The range of the data covered July 10 – September 24, but the bulk of the data are from August. The 8:00 p.m. to 2:00 a.m. time window was used since this is the time period when suckers are typically at their highest densities in the sampling (Laeder and Wilkens 2010 p. 8).
We first transformed the total number of suckers captured in a single day into an estimate of the density of suckers, i.e. the number of suckers per acre foot of water sampled (Figure).

SAF = TS/ (cfs * 1.98346 * m/minutes in a day)

where:
SAF = the number of suckers per acre foot of water;
TS = the total number of suckers captured in a given day, i.e. the sum of the 6 subsamples;
cfs = the mean daily flow of water through A Canal head gates in cubic feet per second; and
m = the total amount of time sampling occurred summed across the 6 subsamples in minutes.
The constant 1.98346 is a conversion factor to convert cfs to acre feet in a given day, and the total number of minutes in a day is 1,440.

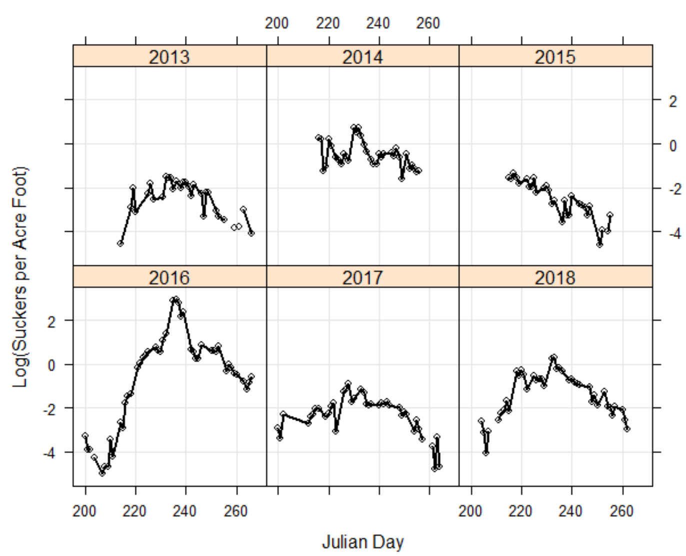

Figure A1. The natural log of the number of suckers captured in the FES per acre foot of water sampled on a given day for 2013 – 2018 (data from BOR).

For example, on August 10, 2016, 262 suckers were captured in the six 30-minute subsamples, 23, 32, 44, 67, 54, and 42 suckers, respectively. The average cfs flowing through the A Canal on that date was 798. Therefore, the number of suckers per acre foot of water was 1.3.

1.3 SAF = 262 TS/(798 cfs *1.98346*180 /1440)

This value was calculated for every day of sampling for the years the standardized data exist: 2013 – 2018. We then used a linear regression to estimate the average number of suckers per acre foot of water on a given date during the sampling season.

$\ln(SAF) = JD + JD^2$

The term JD is the Julian Day. This is simply the number of days since January 01. For example, the Julian Day for August 10 is 222. The squared term (JD^2) was included because the data exhibited a humped pattern with catches generally higher from mid-August to early September.
The fitted model terms are:

$SAF = -69.9 + 0.59*JD - 0.0013*JD^2$

The fitted model captures the general seasonal pattern in the data, though there is substantial variation among years. However, these data represent the best available information for sucker densities.

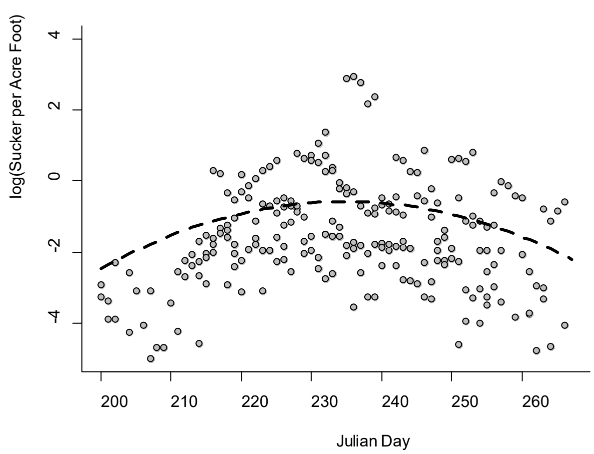

Figure A2. Fitted linear model (dashed line) and raw data for sucker density in catches at the Fish Evaluation Station across the season.

We then used daily A Canal flows (as modelled by the proposed action) from the period of record and the estimate of average daily sucker density (SAF) to estimate the total number of suckers that would be bypassed through the FES in a year. This was a two-step process. First, estimate the total number of bypassed suckers on a given day. Second, sum these values within years to estimate the total number of suckers bypassed through the FES each year of the period of record.

Total annual FES take = Sum(TDAF * 0.25 * SAF)

The value TDAF is the total daily acre feet as generated by the proposed action for each day in the period of record (1981 – 2016). The factor 0.25 was used to account for the 6-hour period in which suckers are expected to be present in the bypass and when samples of occurred (8:00 p.m. – 2:00 a.m.), which is one-quarter of a day.

Based on this approach, the median annual take for the period of record is 8,383 (range: 204 – 11,969). Based on data from the year with the highest captures (2016), a maximum of approximately 58,000 (33,000 – 100,700) would be expected to be entrained in a given year (USBR 2017).

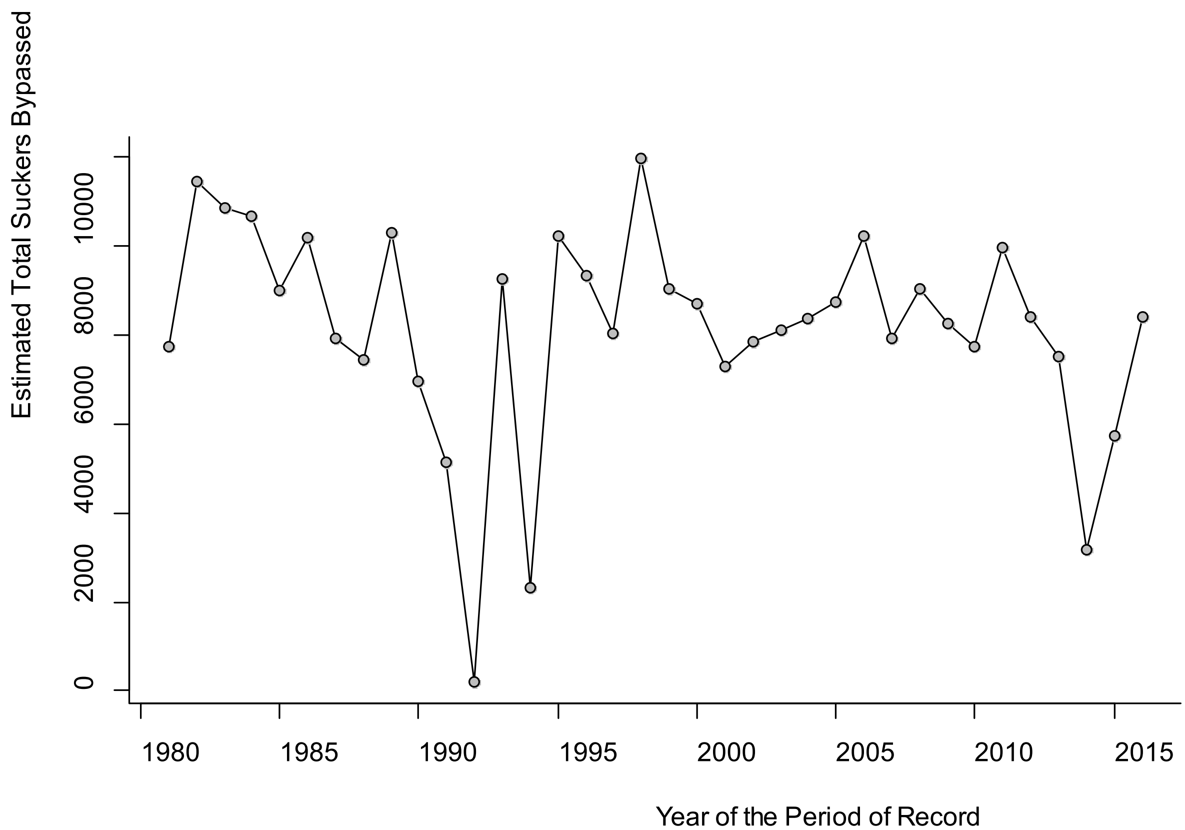

Figure A3. Estimated annual take at the FES for the period of record.