United States Department of the Interior

FISH AND WILDLIFE SERVICE
California/Nevada Operations Office
2800 Cottage Way, Room W-2606
Sacramento, California 95825

In Reply Refer To: 1-10-01-F-018-4

APR - 5 2001

Memorandum

To: Regional Director, Bureau of Reclamation
Sacramento, California

From: Manager, California/Nevada Operations Office
Sacramento, California

Subject: Bureau of Reclamation's Proposed Operation of the Klamath Project

This document transmits the Fish and Wildlife Service's (Service or FWS) biological/conference opinions (BO) based on our review of the subject action in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 et seq.). At issue are the effects of the proposed action on the endangered Lost River sucker (*Deltistes luxatus*; LRS), endangered shortnose sucker (*Chasmistes brevirostris*; SNS), threatened bald eagle (*Haliaeetus leucocephalus*), and proposed critical habitat for the Lost River and Shortnose suckers (collectively referred to as "suckers").

This BO was prepared with the knowledge that project inflow for 2001 indicates this is likely to be the driest year on record. The allocation of extremely limited water resources will inevitably result in major impacts to the Klamath Project and the Klamath River Basin. Very little water will be available for agriculture this year, and there is insufficient water to fully provide for the needs of species in project reservoirs and the Klamath River. Water will be largely unavailable for the National Wildlife Refuges located within the Project boundaries, where water supply for waterfowl and the food supply for resident and wintering eagles will be severely depleted.

Drought conditions in the Klamath Basin are severe this year, but scarce water availability is not unique to the Klamath Project and the Klamath River Basin. The extreme conditions this year emphasize the urgent need to engage all parties with interests in the water resources of the Klamath Project and the Klamath River Basin in serious discussions regarding long-term goals for Project operations and water allocation in the River basin, including upstream and downstream water diverters. Long-term solutions regarding water quality and quantity must be developed.

The Service and Reclamation are charged with ensuring that operation of the Klamath Project does not jeopardize continued existence of endangered and threatened species or adversely modify their critical habitat. Incorporated in this BO are conservation recommendations intended to encourage long-term solutions to water resource allocation in the Project and in the Klamath River Basin. The Service supports the initiation of a process to develop long-term solutions and stands ready to participate and assist in developing solutions that will help avert the need to make difficult decisions with major impacts in the Klamath Project and in the Klamath River Basin during low water years.

This BO is issued in response to the Bureau of Reclamation's (Reclamation or USBR) final biological assessment (BA) for operation of the Klamath Project, which was received by the Service on February 13, 2001. Although the Bureau's request for consultation did not include the bald eagle, an analysis of Project effects on the eagle is included in this BO for the reasons discussed in the "Consultation History" section of this document.

On March 30, 2001, Reclamation formally requested that this BO remain valid only until April 1, 2002. Reinitiation of formal consultation will be necessary to address Reclamation's continued operation of the Project beyond April 1, 2002. To assist Reclamation in planning for long-term operation of the Project and in recognition of Reclamation's request to complete this consultation by April 2, 2001, we have retained the scope of analysis of effects of the proposed action on listed species/proposed critical habitat used in the March 13, 2001, draft of this BO which was based on the project description in Reclamation's final BA, dated February 13, 2001.

This BO is based on: (1) information presented in Reclamation's final BA dated February 13, 2001; (2) information presented in previous BAs and BOs addressing operation of the Project; (3) information obtained from Reclamation in meetings regarding operation of the Project, and from the results of ongoing field research activities; (4) information provided in published and unpublished reports on the biology, distribution, systematics, and status of the affected listed species and the ecosystems upon which they depend; (5) communications with field researchers who have conducted, or are now conducting, research on the biology of affected listed species or the ecosystems upon which they depend; (6) other available commercial and scientific information; and (7) comments and reports received in response to reviews of the March 13, 2001, draft BO. A complete administrative record of this consultation is on file at the Service's Klamath Falls Fish and Wildlife Office.

This BO supercedes all previous Project-related BOs, except for those related to acrolein and other chemical applications, and portions of the 1996 BO addressing operations of PacifiCorps and the New Earth Company. It is our understanding that Reclamation is currently consolidating new information regarding the chemical application-related BOs and will reinitiate consultation on these actions in the near future. Based on new information developed since 1996, consultation on actions related to the operations of PacifiCorps and the New Earth Company addressed under the 1996 BO will be reinitiated as well.

BIOLOGICAL/CONFERENCE OPINION
REGARDING THE
EFFECTS OF OPERATION OF THE
BUREAU OF RECLAMATION'S KLAMATH PROJECT
ON THE
ENDANGERED LOST RIVER SUCKER (*Deltistes luxatus*)
ENDANGERED SHORTNOSE SUCKER (*Chasmistes brevirostris*)
THREATENED BALD EAGLE (*Haliaeetus leucocephalus*)
AND
PROPOSED CRITICAL HABITAT FOR THE LOST RIVER/SHORTNOSE SUCKERS

Prepared
by
Klamath Falls Fish and Wildlife Office
April 2001

Executive Summary

This document addresses the effects of operation of the Bureau of Reclamation's (Reclamation) Klamath Project (Project) for 2001 on the endangered Lost River sucker (LRS), endangered shortnose sucker (SNS), threatened bald eagle, and proposed critical habitat for the LRS and SNS (collectively, suckers). The Project delivers water to about 220,000 acres of irrigated agriculture in the upper Klamath River Basin (Basin) in south-central Oregon (Klamath County) and northern California (Modoc and Siskiyou counties), as well as to the Tule Lake and Lower Klamath National Wildlife Refuges (NWRs). The Project consists of three main reservoirs with a total surface area of about 100,000 acres, many miles of canals and ditches, and numerous water control structures, pumps, and other structures. Interrelated and interdependent with the proposed action is operation of Pacific Corps's hydroelectric facilities on the Link River and New Earth Corporation's algae harvest facility at the "C-drop" off of the A-canal.

Previous biological opinions (BOs) for the Project included determinations by the Fish and Wildlife Service (Service) that implementation of the action, as proposed, was likely to jeopardize the continued existence of the LRS and SNS. The two endangered sucker species are endemic to the Basin. The three major Project reservoirs [Upper Klamath Lake (UKL), Clear Lake, and Gerber Reservoir] represent their primary habitats. Tule Lake once supported a large population of suckers but habitat conditions there are now so degraded that only a few hundred suckers remain. Sucker populations in Clear Lake and Gerber Reservoir appear healthy, but are vulnerable to the adverse effects of droughts. Sucker populations in the Tule Lake sump are extremely small and population viability is at risk from reductions in water depth, adverse water quality, and lack of access to spawning areas. Sucker populations in UKL are at risk of extirpation from adverse water quality, loss of habitat, entrainment, and lack of passage. Populations of LRS are most at risk because self-reproducing populations are found in only two reservoirs and the viability of these populations is not assured.

The environmental baseline for the suckers is characterized by degraded aquatic ecosystems throughout the Basin. The baseline has been adversely affected over the past 150 years by agriculture, grazing, forestry, and to a smaller degree, urbanization. Development of the Project and interrelated and interdependent actions have been the major factors contributing to the loss and degradation of aquatic habitats in the Basin, and the endangered status of the two suckers. Nearly all Basin streams and rivers have been degraded, some seriously, by the loss of riparian vegetation, geomorphic changes, introduction of return flows from agricultural drainage ditches and water pumped from drained wetlands, stream channelization, dams, and flow reductions from agricultural and hydroelectric diversions. Most water bodies in the Basin fail to meet state water quality criteria. Wetland losses have been especially significant since they provide habitat for larval and juvenile suckers and have crucial water quality functions. Along the perimeter of UKL, about 40,000 acres of wetlands have been diked and drained for agriculture; elsewhere in the Basin, wetland losses are even larger.

Restoration of wetlands and riparian habitats on private and public lands, and implementation of Clean Water Act regulations (e.g., Total Maximum Daily Load limits) will bring much needed water quality and habitat improvements and will reduce threats and contribute to the conservation

of the suckers. However, it has taken over a century to create the current conditions in the Basin, and it will take decades for restorative actions to be fully implemented and functional.

At UKL, implementation of the action, as proposed, is likely to have the following effects on the suckers and their proposed critical habitat:

1. Significantly increase the loss of larval and juvenile sucker habitat at critical phases of their life cycle which will reduce the frequency and magnitude of year-class development;

2. Significantly increase the loss of all life stages, but especially larvae, through entrainment;

3. Block passage of suckers into areas of preferred habitat or to spawning areas which will reduce their survival and reproduction;

4. Increase the frequency and magnitude of potentially lethal water quality conditions by lowered lake levels which will optimize light and nutrient conditions that will facilitate algal blooms. These blooms adversely affect the survival of all life history stages of the suckers, and the reproduction of adults;

5. Contribute to poor water quality conditions during algal decay cycles by reducing lake volume/surface ratios that influence dissolved oxygen concentrations. These conditions will adversely affect the survival of all sucker life history stages, but will especially reduce the number of adults, and limit their longevity and reproductive potential;

6. Contribute to the loss of or reduction of access of suckers to water quality refuge areas that are critical to ensure adult sucker survival; and

7. Reduce lake volume/surface ratios during winter ice-cover conditions that influence dissolved oxygen concentrations which will contribute to potentially lethal water quality conditions that could adversely affect adult and juvenile survival.

At Clear Lake, Gerber Reservoir, and the Tule Lake sump, implementation of the action, as proposed, is likely to have the following effects on the suckers and their proposed critical habitat:

1. Block passage of suckers into areas of preferred habitat or to spawning areas in Clear Lake and the Tule Lake sump, which will reduce sucker survival and reproduction;

2. Reduce water volume in summer and fall when water temperatures and respiration rates are high and lead to stressful/lethal conditions for suckers, and also make them more vulnerable to disease and predators; and

3. Reduce water volume/surface ratios during winter ice-cover conditions that influence dissolved oxygen concentrations which will contribute to potentially lethal water quality conditions that are likely to reduce adult and juvenile sucker survival.

Collectively, these effects are likely to appreciably reduce the survival and recovery of the suckers and appreciably diminish the value of the primary constituent elements of proposed sucker critical habitat. On that basis, the Service concludes that implementation of the Project, as proposed, in calendar year 2001 is likely to jeopardize the continued existence of the suckers and adversely modify their proposed critical habitat.

The proposed action is likely to result in a significant reduction or elimination of the prey base for the bald eagle in the Basin due to reduced or curtailed water deliveries to areas that contain important eagle feeding habitat. Water deliveries to critical wetlands in Tule Lake and Lower Klamath NWRs attract millions of migrating waterfowl and hold a portion of them through the winter, thereby providing food for bald eagles. The wintering population of bald eagles on the refuges is one of the largest outside of Alaska. It includes birds from Canada, the Pacific Northwest, and California and consists of 150 to 900 eagles annually. Although these effects are considered significant, the Service has concluded that they are not likely to jeopardize the continued existence of the bald eagle.

A RPA has been developed for the proposed action that avoids effects that are likely to jeopardize the continued existence of the suckers and adverse modification of their proposed critical habitat. The RPA requires: (a) maintenance of minimum lake elevations in Project reservoirs; (b) coordination with the Service and the National Marine Fisheries Service in the development of Project operation plans during low water years; (c) adaptive management of water quality through monitoring and reporting; (d) installation of screens at the A-canal and Link River Dam; (e) adequate passage facilities at Link River Dam; (f) habitat and water quality improvements; and (g) additional studies to be completed to obtain information that Reclamation can use to refine reservoir management to adequately protect the suckers and their proposed critical habitat.

With implementation of the RPA, incidental take of suckers is anticipated. Under the Incidental Take Statement in this BO, Reclamation is required to implement reasonable and prudent measures (RPMs) to minimize the impacts of that take. Some of these measures were previously required, but have not yet been implemented or completed. Incidental take of bald eagles is also anticipated and this opinion also includes RPMs to minimize the impacts of that take.

This BO supercedes all previous Project-related BOs, including that portion of the Service's 1996 BO on Pacific Corp's operation of the Link River Dam and New Earth Company's operation of the C-drop harvest site, and excepting those BOs associated with Reclamation's application of acrolein and other chemicals.

I.1 CONSULTATION HISTORY

Consultation History

The Bureau's request for reinitiation of consultation on the 1992 BO was received by the Service on December 18, 1999, and acknowledged in writing on December 29, 1999.

On April 26, 2000, Reclamation provided the Service with a memorandum stating "the BA will be provided to the Service on about June 1, 2000."

On June 20, 2000, the Service provided written clarification on what the Act required in an adequate BA, including comments on the draft "Preliminary Report Describing Historic Project Operations."

On September 2, 2000, Reclamation provided the Service with a letter stating that "Reclamation now anticipates that the BA will be provided to the Service on October 1, 2000."

On September 27, 2000, the Service received a schedule from Reclamation outlining the on-going consultation on the Project showing that the draft BA would be provided to the Service in October 2000.

A draft BA was provided to the Service on November 8, 2000, and the Service provided written comments on November 21, 2000.

A second draft BA was provided to the Service on November 22, 2000, and the Service provided additional written comments on December 19, 2000. Additional written comments were sent to Reclamation on January 19, 2001.

The final BA was received on February 13, 2001, about 45 days prior to the start of Project operations in April.

New information on the potential adverse effects of low lake levels on suckers, developed since the1992 BO, and massive sucker die-offs in UKL in the 1990s, indicated that higher minimum UKL levels were necessary to reduce the risk of extinction of the suckers. Some of the new information was utilized by Reclamation to manage UKL, beginning in 1997, with a new minimum September 30 elevation of 4139 ft (Table I-2). This new information was also used by Reclamation in September 2000, when it sent a letter to the Service describing the need to maintain a minimum surface elevation of 4139.0 ft in UKL by September 30 to avoid violation of section 7(d) of the Act (Table I-2).

Table I-2. Upper Klamath Lake minimum surface elevations (in feet above mean sea level).

Date	1992 BO	1997-200 "Low Range Elevations"	2001 BA Minimums
April	4141	4142.6	4141.1
May	4141	4142.6	4140.4
June	4139 (4137)[1]		4139.5
July	4139 (4137)[1]	4141.6	4138.8
August	4139 (4137)[1]		4137.5
September	4139 (4137)[1]	4139	4136.8
October	4139		4136.9
November	4139		4137.8
December	4139	4140	4138.6
January	4139		4139.5
February	4139	4141.5	4140.1
March	4141		4141.1

[1] The minimum surface elevation of 4139 ft could be compromised in no more than 4 of 10 years with a minimum elevation of 4137 ft. The lowest proposed minimum September 30 surface elevation in the final BA is 4136.8 ft. (Table I-2), which is more than 2 ft below the elevation Reclamation previously considered minimally necessary to protect the suckers, and is more than 3 ft below the level that the Service recommended in its informal consultation stage, technical assistance memos dated December 19, 2000, and January 19, 2001.

Table I-3, below, summarizes previous section 7 consultations on the Klamath Project. A portion of the information used in this BO is available on Reclamation's web site: http://www.mp.usbr.gov/kbao/esa/index.html.

Table 3. Consultation history for the Klamath Project.

Date	Subject of Consultation	Affected Listed Species	Determination
June 14, 1989 (superceded by this BO)	Formal Consultation--Use of Acrolein in Canals and Drains within the Klamath Project Service area.	Shortnose sucker Lost River sucker	Likely to jeopardize.
August 14, 1991 (superceded by this BO)	Formal Consultation-- Effects of the 1991 operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
January 6, 1992 (superceded by this BO)	Formal Consultation-- Effects of the 1992 operation of the Klamath Project (interim biological opinion)	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Not likely to jeopardize the sucker species or the Bald Eagle. No effect to the American Peregrine Falcon.
March 27, 1992 (superceded by this BO)	Reinitiation of Formal Consultation--Effects of the 1992 operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
May 1, 1992 (superceded by this BO)	Reinitiation of Formal Consultation--Effects of the 1992 operation of the Klamath Project at Clear Lake Reservoir.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	No jeopardy to the affected species.
July 22, 1992 (superceded by this BO)	Formal Consultation--Effect of the long-term operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
February 22, 1993 (superceded by this BO)	Reinitiation of Formal Consultation on the long-term operation of the Klamath Project - Upper Klamath Lake operations.	Shortnose sucker Lost River sucker	One-year modification of lake elevation 4141.0 on March 1, 1993.
August 11, 1994 (superceded by this BO)	Reinitiation of Formal Consultation on the long-term operation of the Klamath Project, with special reference to operations at Clear Lake Reservoir.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Established new minimum elevation for Clear Lake Reservoir.
February 9, 1995 (superceded by this BO)	Formal Consultation on the use of pesticides and fertilizers on Federal lease lands and acrolein and herbicide use on the Klamath Project rights-of-way located on the Klamath Project (reinitiation of consultation on the use of acrolein for aquatic weed control in Reclamation canals and drains).	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon Applegate's milkvetch	Not likely to jeopardize the sucker species. No effect to the Bald Eagle, American Peregrine Falcon, or Applegate's milkvetch.

February 2, 1996 (superceded by this BO)	Reinitiation of Consultation on the use of pesticides and fertilizers on federal lease lands and acrolein and herbicide use on the Klamath Project rights-of-way located on the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Not likely to jeopardize the affected species.
July 15, 1996 (superceded in part by this BO)	Reintiation of Consultation on PacifiCorp and The New Earth Company Operations, as Permitted by the Bureau of Reclamation on the Klamath Project	Shortnose sucker Lost River sucker	Not likely to jeopardize the affected species.
April 2, 1998 (superceded by this BO)	Amendment to July 22, 1992 BO to extend date for completion of A-canal screen until 2002	Shortnose sucker Lost River sucker	Not likely to jeopardize the affected species.
April 20, 1998 (superceded by this BO)	Amendment to the 1992 BO to cover Operation of Agency Lake Ranch Impoundment	Shortnose sucker Lost River sucker	Not likely to jeopardize the affected species.
April 21, 1998 (superceded by this BO)	Amendment to July 15, 1996 consultation on PacifiCorp and The New Earth Company Operations, as Permitted by the Bureau of Reclamation on the Klamath Project	Shortnose sucker Lost River sucker	Not likely to jeopardize the affected species.
July 13, 1998 (superceded by this BO)	Amendment to the 1992 BO dealing with Anderson-Rose releases	Shortnose sucker Lost River sucker	Not likely to jeopardize the affected species.
April 15, 1999 (superceded by this BO)	Amendment to the 1996 BO addressing lowered water levels in Upper Klamath Lake to reduce risk of flooding in spring 1999	Lost River sucker Shortnose sucker	Not likely to jeopardize the affected species.
August 18, 1999 (superceded by this BO)	Amendment to the 1995 BO on use of pesticides and fertilizers on leased lands and use of acrolein in canals operated by the Langell Valley Irrigation	Lost River sucker Shortnose sucker	Not likely to jeopardize the affected species.
September 10, 1999 (superceded by this BO)	Revised amendment to the 1992 BO to cover operations and maintenance of Agency Lake Ranch impoundment	Lost River sucker Shortnose sucker	Not likely to jeopardize the affected species.

History of Previous Biological Opinion Requirements Being Incorporated

The BA describes Reclamation's compliance with reasonable and prudent alternatives, and terms and conditions associated with 1992, 1994, and 1996 BOs (Service 1992, 1994b, 1996). For the most part, Reclamation has complied with those requirements (USBR 2001). However, several requirements from previous biological opinions that were not completely satisfied, as discussed below, are incorporated in this BO.

A-Canal Screening

Reclamation was required to reduce entrainment of larval, juvenile, and adult suckers into the A-Canal by July 1997. In 1995, Reclamation provided a grant to the Klamath Irrigation District (KID) to evaluate sucker entrainment and identify alternatives for entrainment reduction. A final report was completed in 1997 (Natural Resource Scientists 1997). Several meetings were held in 1995 and 1996 to discuss this issue with representatives of the KID, Tule Lake Irrigation District (TID),

Oregon Department of Fish and Wildlife (ODFW), Cell Tech, Reclamation and the Service. From these meetings, the group agreed that entrainment reduction strategies and associated fish passage issues at Link River Dam should be integrated.

Subsequently, the UKL Entrainment and Fish Passage Working Group was formed to integrate all fish entrainment and passage issues. The working group consists of Reclamation, Klamath Tribes, Service, KID, Cell Tech, PacifiCorp, TID, and ODFW. Reclamation facilitated meetings 2-3 times per year from 1997 through 1999 to discuss progress and recommend future activities.

In 1997, the Service requested that Reclamation conduct additional entrainment monitoring on the A-Canal to compare with entrainment monitoring data from Link River Dam and B- and C-Canals. Reclamation funded an A-Canal fish entrainment monitoring study in 1997 and 1998 (Gutermuth et al. 2000a). In 1998, Cell Tech evaluated several mesh sizes of wedge-wire screen material to determine debris loading characteristics and sizes of fish that were excluded (Gutermuth 1999). On April 2, 1998, the Service amended the July 22, 1992, BO extending the date for entrainment reduction to July 22, 2002.

In 1999, Reclamation's Klamath Basin Area Office hired a fish passage biologist to coordinate Reclamation's fish entrainment and passage activities. The University of Wyoming was contracted to conduct swimming performance tests of juvenile LRS suckers in a range of water temperatures to help with the development of fish screen facility criteria (Meyer 1999). In 1999, Reclamation also performed field evaluations of Reclamation's Universal Stream Bottom Retrievable Flat Plate Fish Screen. Preliminary results were promising and plans were made to test two, 100 cubic feet per second (cfs), Reclamation-designed screens in the A-Canal during the 2000 irrigation season. Reclamation proceeded with the development of preliminary designs for the test installation during the fall of 1999 and developed draft specification and final drawings of the screens in the spring of 2000.

In a March 29, 2000, letter to Reclamation, KID did not support the testing of Reclamation's prototype screen and instead wanted to pursue other flat plate screen alternatives. Reclamation and KID met with the Service and ODFW to discuss the conceptual screen designs and identify acceptable design criteria. Reclamation has provided KID with a grant to develop preliminary designs for A-Canal screens.

On June 29, 2000, the Service met with ODFW and KID to develop screening criteria. The agreed-upon screening criteria was to be that used by the National Marine Fisheries Service (NMFS) in the Pacific Northwest, with several minor exceptions (Appendix 1).

Link River Dam Fish Ladder

A July 15, 1996, BO addressing PacifiCorp and New Earth Corporation operations as permitted by Reclamation required that Reclamation complete a fish ladder report by December 31, 1998 (Service 1996). That report has not been completed. Reclamation has been working on fish passage issues since early 1998, when the Service requested Reclamation lead the UKL Entrainment and Fish Passage Working Group. Reclamation, with assistance from fish passage engineers from the

Denver Technical Service Center, developed conceptual designs for a new ladder at Link River Dam in the fall of 1999 (USBR, unpubl. data). The Service has not seen these designs.

Other Biological Opinion Requirements

The 1992 BO required that Reclamation develop and implement a long-term plan to avoid and minimize incidental take associated with the Project. A draft plan was developed during the summer of 1995 and circulated to the Service and state resource agencies. The Service is not aware that Reclamation has taken any action to finalize or implement this plan.

The 1992 BO also required that Reclamation conduct a comprehensive survey of the Project service area to delineate the location of potential sources of take, develop and implement a program to reduce or eliminate this take, and for education purposes notify landowners and/or irrigation districts that the potential for take exists and advise them of protection afforded listed species under the Act. This activity was to be completed by July 22, 1995. On February 15, 2001, Reclamation provided the Service with an inventory of Project water diversions that potentially entrain endangered suckers; 193 diversions were identified. According to the BA, Reclamation plans to complete the written report by September 2001. Reclamation has not notified the Service of when it plans to take actions to reduce entrainment at these diversions.

Reclamation's Contributions to Sucker Recovery

According to the BA, Reclamation has initiated or completed most of the Priority 1 and 2 action items identified in the *Lost River and Shortnose Sucker Recovery Plan*. Reclamation has funded over $10.5 M in ecosystem restoration projects benefitting the recovery of these species and has purchased the 7,200-acre Agency Lake Ranch.

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II.1 DESCRIPTION OF THE PROPOSED ACTION

A. Definition of the Action Area

The "action area" is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" 50 CFR 402.02. Based on information contained in the description of the proposed action, the status of the species, and the effects of the action, we have determined that the action area for this consultation extends from Iron Gate Dam upstream in the Klamath River to Link River Dam, including Lake Ewauna and Link River; Upper Klamath Lake to its highwater line, and tributaries as far upstream as are affected by Project operations; Clear Lake and Gerber Reservoir to their high water lines, and tributaries as far upstream as are affected by Project operations; the entire Lost River from Clear Lake Dam to the Tule Lake sumps, including all of Miller Creek, and any tributaries of the Lost River that are affected by Project actions. Also included in the action area are dams, canals, drains, and facilities owned or operated, or related by contract or agreement to Reclamation's Klamath Project, and the approximate 220,000 acres of irrigated land serviced by the Project. Service actions on Refuge lands serviced by the Project are not included because they will undergo separate section 7 consultation.

B. Authorizations/Responsibilities/Obligations that Affect or Influence Project Operations

These include:

1. Reclamation Act of 1902. Project construction was authorized by the Secretary of the Interior on May 15, 1905, in accordance with the Reclamation Act of 1902. The Act of February 9, 1905 provides: "The Secretary of the Interior is hereby authorized in carrying out any irrigation project that may be undertaken by him under the terms and conditions of the national reclamation act and which may involve the changing of the levels of Lower or Little Klamath Lake, Tule or Rhett Lake, and Goose Lake, or any river or other body of water connected therewith, in the States of Oregon and California, to raise or lower the level of said lakes as may be necessary...";

2. The Klamath River Compact of 1957. Entered into between the states of Oregon and California and approved by the U.S. Congress, the compact establishes goals and objectives for the development and management of water resources of the Klamath River Basin;

3. Federal Energy Regulatory Commission (FERC) license, Project No. 2082. The license establishes terms and conditions for operation of the Eastside and Westside Powerplants at Link River Dam, J.C. Boyle, Copco No. 1 and No. 2, and Iron Gate hydroelectric projects and Keno Dam. This license sets certain minimum flows at IGD. Minimum flows, however, are subject to water availability and senior water rights. Pursuant to1956 contract with Reclamation, PacifiCorp operates Link River Dam and its appurtenant power generation facilities. Reclamation and PacifiCorp entered into a Letter Agreement on June 5, 1997, to clarify for FERC that PacifiCorp was operating Link River Dam pursuant to Reclamation authority and directives under the 1956 contract, because the 1997 Klamath Project annual operations plan required Klamath River flows that were both greater and less than those in PacifiCorp's FERC license. The Agreement has been extended each year to include that year's operation;

4. Endangered Species Act. Project operations affect four threatened and endangered species including the Lost River and shortnose suckers, southern Oregon/northern California coho

salmon and the bald eagle. In 1992, the Service issued BOs on the effects of the Project on the endangered suckers and the bald eagle; this opinion was amended in 1994. The Service provided "reasonable and prudent alternatives" (RPAs) regarding minimum water elevations in project reservoirs that would allow Project operation to continue without jeopardy to the listed species. A 1996 BO addresses the effects of operations by Reclamation permittees on suckers;

5. Tribal Trust. The United States has a trust responsibility to protect tribal trust resources. In general, the trust responsibility requires the United States to protect tribal fishing, gathering, hunting, and water rights, which are held in trust for the benefit of the tribes. Reclamation is obligated to ensure that Project operations not interfere with the tribes' senior water rights. With respect to the tribes' fishing rights, Reclamation must, pursuant to its trust responsibility and consistent with its other legal obligations, prevent activities under its control that would adversely affect those rights, even though those activities take place off reservation. Fishery and other resources in the Klamath River and Upper Klamath Lake provide religious, cultural, subsistence, and commercial support for the Klamath Basin Indian tribes. The Klamath Basin Indian tribes include the Klamath, Hoopa Valley, Karuk, and Yurok Tribes;

6. Refuge Water Supplies. Four national wildlife refuges lie adjacent to or within Project boundaries-Lower Klamath, Tule Lake, Clear Lake, and Upper Klamath Lake National Wildlife Refuges. The refuges either receive water from, or are associated with Project facilities; and

7. Contracts and Water Rights. The Project supplies water to irrigation districts and individual irrigators pursuant to contracts entered into with Reclamation, subject to the availability of water. These contracts and water rights are described in Reclamation's 1992 BA (Reclamation 1992a) and Report on Historic Operation (Reclamation 2000a). They are further discussed below as well.

C. Reclamation's Proposed Action

The proposed action consists of Reclamation's operation of the Project, as a single entity, in accordance with historic operations. The Project includes a vast array of facilities (e.g., reservoirs, canals, pumping plants, diversions, and drains). These are all managed in concert for the unified purpose of running the Project. A partial description of project operations is presented in the BA prepared in 1992 (USBR 1992a) and a report (USBR 2000a) briefly describing historic project operations. More detailed descriptions of the project features and their operations are presented below under "Project Facilities and Operations".

In 1992 and1994 Bos, the Service determined that the Project would jeopardize the continued existence of the suckers and specified minimum lake and reservoir levels to avoid that effect, but since 1997, Reclamation has been operating at even higher minimum lake/reservoir levels to protect suckers. In this consultation, Reclamation proposes to operate the Project in a manner that meets or exceeds minimum lake levels that occurred during the period from 1960 to 1998. Under this proposal, Reclamation would maintain minimum lake levels that are lower than the levels it agreed to meet or exceed since 1997.

Four water year types are proposed for evaluation based upon inflows: (1) above average (>500,000 acre feet of inflow); (2) below average (312,000-500,000 acre feet); (3) dry (185,000 acre feet); and (4) critical dry (<185,000acre feet). These are determined using Reclamation's

water-routing model (KPOPSIM) that simulates project operation and the effects of varying water deliveries on overall project operation (USBR 2001).

1. Upper Klamath Lake

Reclamation proposes to operate the project to meet or exceed the elevations summarized in Table 1, depending on the water year type. These levels are the minimum end of the month values taken from historic operations (1960-1998). Water operations at Upper Klamath Lake are achieved through a combination of Eastside/Westside power canal releases, Link River Dam releases, A Canal releases, Lost River Diversion Canal releases, and Agency Lake Ranch diversions.

Table 1. Proposed minimum end of the month Upper Klamath Lake elevations by water year type (1960-1998).

Time Step	Above Average Water Years	Below Average Water Years	Dry Water Years	Critical Dry Water Years
October	4138.98	4138.36	4138.18	4136.93
November	4139.55	4138.99	4138.96	4137.80
December	4139.58	4138.80	4139.66	4138.58
January	4139.54	4139.41	4140.26	4140.01
February	4140.56	4140.15	4140.41	4140.94
March	4141.10	4141.35	4141.70	4141.80
April	4142.26	4142.15	4141.68	4141.68
May	4142.85	4142.22	4141.40	4140.70
June	4142.17	4141.30	4140.39	4139.45
July	4140.83	4140.00	4139.10	4138.77
August	4139.66	4138.85	4138.38	4137.52
September	4138.95	4138.18	4137.55	4136.84

2. Clear Lake Reservoir

Reclamation proposes to operate Clear Lake Reservoir to meet or exceed the elevations listed in Table 2, depending on the water year type. These elevations are the minimum end of the month values taken from historic operations (1960-1998).

A Safety of Dams (SOD) project is planned for Clear Lake Dam in 2001-2002 to correct the known safety deficiencies of the existing dam. There are presently operational restrictions upon the reservoir elevations because of the safety deficiencies. Reclamation plans to modify the dam site by constructing a roller-compacted concrete (RCC) embankment structure immediately downstream of the current dam site and subsequently breaching the existing embankment structure. The operational capacity of the reservoir would not change from its present capacity and the operational restrictions on the reservoir would be removed when the project is completed. As part of the SOD project, Reclamation plans to design and install a permanent fish screen on the dam's outlet structure. The screen would be operated during routine irrigation and Project releases, but not during flood releases. The effects of the SOD project are described in the environmental assessment (Reclamation 2000c) and are subject to a future section 7 consultation.

Table 2. Proposed minimum end of the month Clear Lake Reservoir elevations by water year type (1960-1998).

Time Step	Above Average Water Year	Below Average Water Year	Dry Water Year	Critical Dry Water Year
October	4524.00	4521.33	4522.50	4519.30
November	4524.05	4521.47	4522.51	4519.29
December	4524.15	4521.70	4522.80	4519.35
January	4524.30	4521.87	4522.85	4519.40
February	4521.46	4523.37	4527.00	4523.00
March	4526.57	4524.25	4527.10	4522.84
April	4527.52	4525.50	4526.90	4522.75
May	4527.70	4525.10	4526.42	4521.77
June	4526.70	4524.08	4525.65	4521.18
July	4525.70	4522.88	4524.45	4520.44
August	4524.70	4521.90	4523.52	4519.82
September	4524.12	4521.28	4522.75	4519.42

3. Gerber Reservoir

Reclamation proposes to operate Gerber Reservoir to meet or exceed elevations listed in Table 3, depending on water year type. These elevations are the minimum end of month values taken from historic operations (1960-1998).

Table 3. Proposed minimum end of the month Gerber Reservoir elevations by water year type (1960-1998).

Time Step	Above Average Water Year	Below Average Water Year	Dry Water Year	Critical Dry Water Year
October	4815.18	4794.27	4797.98	4796.62
November	4815.16	4795.93	4797.96	4796.62
December	4815.20	4798.80	4798.04	4797.06
January	4816.58	4799.14	4798.18	4798.79
February	4802.23	4803.80	4804.82	4800.74
March	4821.30	4809.00	4804.18	4801.28
April	4827.30	4812.37	4808.26	4801.14
May	4827.00	4810.35	4808.10	4798.86
June	4824.10	4807.88	4803.60	4798.36
July	4820.81	4804.13	4799.22	4797.73
August	4817.98	4801.24	4798.60	4797.01
September	4815.26	4794.47	4798.08	4796.52

Reclamation's Denver Technical Service Center recently completed a cursory review of existing information to determine the feasibility of raising the active storage capacity of Gerber Dam by three feet. The review indicates that raising the dam is a viable option for increasing water storage in the Klamath Basin, although additional studies are needed to support this determination. Reclamation is beginning an appraisal study on raising the dam. Reclamation anticipates that this study will be completed in 2001. The additional water storage could be used to maintain minimum in-stream flows in Miller Creek for native fish, including endangered suckers, or for other Project purposes. Modification of the dam would be the subject of a future section 7 consultation.

4. Lost River Dams/Diversion Facilities

Reclamation proposes to operate Malone, Wilson, and Anderson-Rose dams and associated diversion facilities consistent with historic operations.

5. Agency Lake Ranch

In 1998, Reclamation acquired the 7,123-acre Agency Lake Ranch on the west side of Agency Lake at the north end of Upper Klamath Lake. The ranch property, comprised of former agricultural croplands and pasture, is being used to store additional water for Project use that would otherwise be spilled to the Klamath River during periods of high runoff. In 2000, approximately 15,000 acre feet of additional water was stored on the ranch and subsequently pumped into Agency Lake for overall Project purposes. Reclamation proposes to continue operation of Agency Lake Ranch to store Project water.

Existing dikes surrounding the ranch could be raised to store up to 35,000 to 40,000 acre-feet of spill water. Reclamation has started a process for developing a long-term operations plan for the property. Modifications will be the subject of future consultation.

6. PacifiCorp and The New Earth Company

PacifiCorp and The New Earth Company (New Earth), two private corporations, have operations that are closely linked to the Project in the Upper Klamath Basin. New Earth harvests algae from Klamath Project canals and is required to obtain a permit from Reclamation for this activity. It has recently proposed major expansion of its facilities to harvest all water entering the A Canal and is seeking a permit amendment. PacifiCorp operates Link River Dam pursuant to a contract with Reclamation which provides for regulation of Upper Klamath Lake levels and Klamath River flows, although Reclamation has reserved the right to operate the Dam. PacifiCorp also operates diversion facilities at Link River Dam for power generation (USBR 1996). The operation of these facilities are interrelated and interdependent with Project operations.

PacifiCorp Hydrofacilities Operations

PacifiCorp operates its facilities at the Westside and Eastside Plants at Link River Dam, Keno Dam, J. C. Boyle Dam, Copco No. 1 and Copco No. 2, and Iron Gate Dam as described in Reclamation's 1996 BA (Reclamation 1996a). A more detailed review of these facilities and operations, and a review of resource information is presented in the First Stage Consultation Document (FSCD) for the Klamath Hydroelectric Project (PacifiCorp 2000); information derived from this document is discussed below. The FSCD is being prepared in conjunction with the development of a hydroelectric license application that will be filed with FERC. PacifiCorp is operating pursuant to a license with FERC that expires in 2006 and a biological opinion dated July 15, 1996 (Service 1996). PacifiCorp, in November 1996, completed a flood operations review and risk assessment for Upper Klamath Lake. The proposed minimum "low range" elevations

posed little threat to the overtopping of dikes around UKL except for February 15 when the "low range" elevation is 4141.5 feet. This elevation lies between the 100-year flood value of 4141.3 feet and 4142.1 feet for the 50-year flood value. Reclamation determined that PacifiCorp's operations are covered under the 1996 BO and did not address these operations in the BA submitted for this consultation.

New Earth /Cell Tech Operations

New Earth operates and maintains an algae harvesting and processing facility at the head end of the C Canal under permit by Reclamation. A detailed description is provided in Reclamation's 1996 BA (Reclamation 1996a) and the 1996 BO (Service 1996). Reclamation determined that New Earth's operations are covered under the 1996 BO and did not address them in the BA submitted for this consultation.

7. Conservation Measures Included in the Action

Reclamation proposed seven conservation measures as part of its proposed action, which are listed below. The Service assumes that Reclamation will begin planning and implementing these measures beginning in 2001, that significant progress will be made until the measures are fully implemented, and that Reclamation will provide annual updates on progress. Because the Service considered timely implementation of these measures in its conclusions in this biological opinion, failure to complete the measures in a timely manner may trigger reinitiation of formal consultation on the Project pursuant to 50 CFR 402.16.

Water Supply

Reclamation proposes to continue to support funding and implementation of the Water Supply Initiative and Klamath Basin Water Supply Enhancement Act (P.L. 106-498). These activities would allow Reclamation to potentially increase and/or enhance Project water supplies.

Selected 1992/1994 BO Measures

Reclamation proposes several specific action items that fall within the existing 1992/1994 BO measures that, when implemented, will reduce the impact of the proposed action and assist in developing critical information for future operational decisions:

<u>Ongoing Mitigation Measures from 1992 BO</u>

1. Life history, population dynamics, and environmental factors affecting suckers.

Continued monitoring of sucker populations is essential to determine if sufficient progress is being made toward protection and recovery of the endangered suckers. Reclamation proposes to continue to support UKL sucker population status studies. UKL population monitoring objectives include: obtaining adult population indices and year class structure; and collecting information focused on evaluation of management and ecosystem restoration actions.

2. Investigate feasibility of new storage in Lost River system.

In 1998, Reclamation initiated a study in cooperation with the Klamath Compact Commission and the Department of Water Resources (Oregon and California) to evaluate a wide range of alternatives for supplemental water supplies in the Upper Klamath Basin. The Oregon Department of Water Resources in cooperation with USGS is studying groundwater in the Upper Klamath

Basin. Reclamation hired a water conservation specialist to work with irrigation districts to conserve water and improve water quality. Also refer to the Klamath Basin Water Enhancement Act (P.L. 106-498).

Selected Reasonable and Prudent Alternatives, Reasonable and Prudent Measures, and Terms and Conditions from the 1992/1994 BOs

1. The Project must be operated to assure a minimum surface elevation of 4034.6 feet from April 1st through September 30th of each year. A minimum elevation of 4034.0 feet must be maintained from October 1st to March 31st of each year.

2. A minimum flow of 30 cfs must be maintained in the Lost River below Anderson-Rose Dam for at least 4 weeks beginning April 15 of each year to allow spawning and return of adults and larval suckers.

3. Salvage Lost River and shortnose suckers that remain in the canal systems that emanate from Upper Klamath Lake, Clear Lake Reservoir, Tule Lake, and Gerber Reservoir after these canals have been shut down and drained.

4. Reclamation shall conduct an annual salvage of suckers stranded in the canal systems and below outlet structures of dams. A salvage plan must be presented to the Service and appropriate state agencies for their approval prior to any salvage operation.

Clear Lake Dam Fish Screen

Reclamation also proposes to design and construct a fish screen on the outlet structure of Clear Lake Dam. This screen would be installed in 2001-2002 concurrent with the construction of the replacement dam. The screen would be operated during normal irrigation operations but not during flood release events. Clear Lake Dam construction and breaching of the existing dam will be the subject of a future section 7 consultation.

Raising Gerber Dam

Reclamation would also investigate the potential for raising Gerber Dam 2-4 feet (ft). The additional water storage would be used to maintain minimum instream flows in Miller Creek for native fish including endangered suckers or other Project purposes.

Entrainment Inventory

Reclamation proposes to inventory potential entrainment sites and develop an entrainment reduction plan prioritizing sites based on relative impacts to the species.

Tule Lake Land Rotation

Tule Lake sumps have been filling in with sediment since project development in the early 1900s and currently provide marginal habitat for endangered suckers. Waterfowl and bald eagle use of this area has also declined over the years due to habitat degradation. Wetland/agricultural land rotation has been identified as a potentially viable management strategy to restore wetland and lake ecosystem function and also support continued agricultural use concurrently. The Service and Reclamation have initiated pilot wetland/agricultural land rotation studies. Reclamation will assist the Service in the implementation of the wetland/agricultural land rotation program and support water quality and fish monitoring to assess the effectiveness of the program.

Lost River and Shortnose Sucker Recovery Plan

The existing recovery plan was written in 1993. Substantial new scientific information has been collected on sucker life history requirements, population status, and limiting factors. A revision of the Plan is necessary to provide criteria for species recovery and a strategy for restoration. Reclamation proposes to assist the Service with this revision.

8. Project Operations

8.A. General

The Klamath Project stores water in Upper Klamath Lake (Klamath River System) and in Gerber and Clear Lake Reservoirs (Lost River system). The distribution system delivers water via a system of canals to lands in the Langell Valley, Poe Valley, Klamath Irrigation District, Tule Lake area, and Lower Klamath Lake area. The primary diversion points include Malone and Miller Creek Diversion Dams in the Langell Valley, diverting Lost River (Clear Lake releases) and Miller Creek (Gerber Reservoir releases) respectively; the Lost River Diversion Dam and Channel, controlling diversions into and out of the Klamath River; the A-Canal diversion works on Upper Klamath Lake, controlling water to the Klamath Irrigation District as well as the Poe Valley and the Tule Lake area; the Anderson-Rose Diversion Dam on the Lost River, which also diverts water to the Tule Lake area; and the Ady Canal, which diverts water from the Klamath River into the Lower Klamath Lake area. In addition, Project irrigators divert directly from both the river systems and Upper Klamath Lake (USBR 2000). None of these facilities have fish screens or provide fish passage, except for the fish ladder at Link River Dam which was designed to pass trout.

Typical water delivery operations under the Project begin in late fall, when the Ady and North Canals are used to deliver water from the Klamath River to lands throughout the Lower Klamath Lake area. This water is used to flood irrigate private, federal lease, and Lower Klamath National Wildlife Refuge lands. The drain water is returned to the river via the Straits Drain. Winter flooding is the primary irrigation pattern. Irrigation and refuge water deliveries however, continue throughout the year. Diversions in the Ady and North Canals range from a low during the summer months of 100 cubic feet per second (cfs) to a high of 500 cfs during the late fall and winter.

In March or early April, the A-Canal diversions from Upper Klamath Lake begin. Flows generally begin at about 500 cfs to charge the canal system, with a gradual increase to a peak of near 1000 cfs in May or June. (USBR 1992a) The amount diverted is typically about 20 to 30 percent of the annual outflow from the lake and 50 percent of the summer outflow. (PacifiCorp 2000) This diversion serves the largest area and delivers the most water of any Project feature. Water deliveries typically continue into October. Drainage water from this part of the system can go in one of two different directions. Some returns to the Klamath River with the remainder flowing into the Lost River for reuse by other districts and the Tule Lake National Wildlife Refuge (USBR 1992a). New Earth also operates its algae harvest facility at the C drop of A canal (USBR 1996). Agriculture returns from this diversion, approximately 400 cfs in the summer, enter the Klamath River through the ADY/Straits Drain canal just upstream of Keno dam. In the fall and winter, excess and irrigation drain water from the Lost River Basin and Lower Klamath Lake (a closed system) are added to the total flow of the Klamath River upstream of Keno dam from the Lost River Canal. Such inflow may be as high as 3,000 cfs per month, but is usually from 200 to 1,5000 cfs (PacifiCorp 2000).

Diversions at Miller and Malone Diversion Dams generally begin in April with flows of about 200 cfs. Flows reach a peak of about 400 cfs and are stopped in about October. These diversions

serve about 30,000 acres in the Langell Valley. Drainage water from this system returns to the Lost River.

Diversions at Anderson-Rose generally begin in mid-March with flows of 200 cfs. Flows reach a peak of about 450 cfs and are stopped during October. Anderson-Rose diversions serve the Tule Lake area. All the drainage flows enter the Tule Lake Sump.

The Tule Lake National Wildlife Refuge receives water from the Tule Lake area and from the Lost River. Since the Lost River Basin was a naturally closed basin, Reclamation constructed a pump and tunnel system (pump "D") from Tule Lake to Lower Klamath National Wildlife Refuge. Return flows accrue to Tule Lake and are reused for irrigation before the water is ultimately passed through the pump system and to Lower Klamath Lake where it is used for irrigation and refuge operations. Finally, the water is returned to the Klamath River via the Straits Drain.

In an average year, Gerber Dam, the source of water for the Miller Diversion Dam, releases about 40,000 acre-feet of irrigation water. Clear Lake releases during an average year will be about 36,000 acre-feet. In an average year, Upper Klamath Lake is operated to stay within a set of operational guidelines that provide for irrigation storage, flood protection, ESA requirements, and Tribal trust responsibilities. All water that is not needed to regulate within these guidelines is released to the Klamath River. During an average year the Klamath River release is over 900,000 acre-feet. In addition, 350,000 to 450,000 acre-feet is used by the Klamath Project for irrigation and refuge operations.

The Project also modifies flows in the Lost River and the Klamath River. Lost River flows are significantly reduced below the Lost River Diversion Dam and Anderson-Rose Diversion Dam (USBR 1992). PacifiCorps, under the direction of Reclamation, operates its Klamath River Hydropower Facilities to meet upper Klamath Lake levels and downstream flows in the Klamath River below Iron Gate Dam (PacifiCorps 2000). Original flows follow the typical western pattern of very high flows in the spring followed by very low flows in the late summer and fall. The Project now tends, in most years, to temper the magnitude of these extremes and change the timing of flow patterns (USBR 2000a).

The following discussion is based on an a Reclamation report entitled *Klamath Project Historic Operation*, dated November 2000. This report contains the best available information on how Reclamation proposes to operate the Project. However, the report describes Project operations relative to three water year types (wet, average, and drought) rather than four (above average, below average, dry and critical dry) as discussed in Reclamation's 2001 BA.

1) Wet Year Operations

During wet year operations, full supplies would be available for Klamath River releases below Iron Gate Dam and Project irrigation needs would also be fully met along with the needs of the refuges. During these periods Gerber would be typically spilling water and Clear Lake would be storing all inflow or controlled releases are made to the Lost River. During a high run-off year Upper Klamath Lake may produce as much as 2.4 million acre-feet of net inflow, most of which could not be stored and would have to be bypassed to the Klamath River.

The primary concern during these operations would be for the protection of lives and property. Facilities would be operated to provide for a controlled release of water from the basin. The Lost River is prone to flooding during high runoff periods. A system of dikes in Langell Valley channelizes the flow during these high flow periods.

Water may be bypassed into the lower Lost River (below Wilson Dam) to the sump area in the Tule Lake Refuge when the capacity of the Lost River Diversion to send the water to the Klamath River is exceeded.

It has been necessary to flood the federal lease land in the Tule Lake area, thus delaying the farming operations. This was the case during the 1964-65 flood. In addition, the Lower Klamath area would experience difficulty in the removal of water in time for the planting of crops.

2) Average Year Operations

In most average years the Project water users, including the wildlife refuges, would receive average irrigation. No restrictions would be in place that would effect timing or quantity of deliveries. The average year inflow to Upper Klamath Lake is 1.3 million acre-feet. The Project consumptively uses approximately 350,000 acre-feet including the wildlife refuges. Supplies of irrigation water in the Lost River system depend upon the carryover storage from the previous year. Average inflow to Lost River reservoirs is insufficient to meet irrigation demand without sufficient carryover storage.

3) Drought Year Operations

These operations are described in a Reclamation report entitled “Drought Plan”(USBR 1992a). The following text is excerpted from that report.

In previous drought years, in order to conserve as much water in Upper Klamath Lake as possible, the Project initiated a variance (i.e., reduce flow to below those set forth by the Federal Energy Regulatory Commission) in the Klamath River below Iron Gate. The variance is issued as soon as irrigation supplies are threatened. The variance not only conserves water for irrigation, but also allows for later releases of water for downstream needs in the lower Klamath River.

The primary source of information concerning inflow to the Project reservoirs is from the Soil Conservation Service (SCS). Should the SCS forecast indicate that insufficient water will be available, the Project's **"Drought Plan"** becomes the operational tool for the distribution of limited water supplies. This plan is explained later in detail (USBR 1992a).

8.B. Project Operations Described in 2001 BA

Reclamation describes operations of the Project in its 2001 BA (using historical data) regarding Upper Klamath Lake, Gerber Reservoir, and Clear Lake Reservoir water elevations from October 1960 through September 1998. This period encompasses the time when existing project features/facilities have been in operation and it is the period of hydrological and project operation records incorporated into the water accounting spreadsheet model (KPOPSIM) for the Klamath Project.

Since 1995, Reclamation has operated the Klamath Project according to an annual operations plan. Each of these years through 2000 was an above average water year condition. The most recent annual operations plan is dated April 26, 2000, and covers the period from April 1, 2000, through March 31, 2001. The annual operations plans have been developed to assist Reclamation in operating the Klamath Project consistent with its obligations and responsibilities, given varying hydrological conditions. Project operation has been influenced during this period by events and actions such as: (1) varying hydrological conditions in the watershed from year to year; (2) changes in the Klamath River watershed and lands adjacent to Upper Klamath Lake; (3) changes in agricultural cropping patterns; (4) changes in national wildlife refuge operations; (5) previous consultations under section 7(a)(2) of the ESA; (6) recognition of trust responsibilities for Klamath Basin Indian Tribes, both upstream and downstream of the Project; and (7) obligations and responsibilities described in July 25, 1995, and January 9, 1997, Regional Solicitor's memoranda.

The 37 years of historic April through September net inflow data to Upper Klamath Lake (using 1996 bathymetric data) were used in a statistical analysis to determine the hydrologic year type indicators for the KPSIM water model. The first step was to determine if the data fit a normal distribution. Once this determination was made the arithmetic mean (average) was calculated (500,400 af). Next, the standard deviation (based on the sample) was calculated (187,600 acre-feet). Approximately 68% of the inflow years fall within the range of 500,400 +/ 187,600 af. The average minus one standard deviation equaled approximately 312,000 af. The water years between 500,000 af and 312,000 af are defined as below average inflow. Because there are significant operational spills for inflows above 500,000 af, the upper end of the area defined by the mean plus one standard deviation was not used and 500,000 af was used as the above average indicator. For the boundary between critical and dry, the mean minus 2 standard deviations was calculated and found to be lower than the lowest inflow on record. Since this couldn't be used, percentile rankings were developed for the full 37 years of inflow data and the third percentile was found to be 185,000 af and was used for the dry indicator. Anything below the dry indicator would be classified as a critical dry year. In summary, the net inflows for the four water year types (April through September) are: above average >500,000 af; below average 312,000-500,000 af; dry 185,000-312,000; and critical dry <185,000 af.

8.B.1. Upper Klamath Lake. Table 4 presents historical water surface elevation data for water years 1961- 1998 (October 1960-September 1998) based on PacifiCorp's daily records for the period of operation encompassed by the BA. This table summarizes the historical end of month minimum, maximum and average elevations for each water year type (above average, below average, dry and critical dry). All values are in feet above mean sea level (USBR datum). Figures 1-4 provide a graphical presentation of the historic data. The graphs have boxes with upper and lower bounds representing the average +1 standard deviation and the average –1 standard deviation respectively, and lines running up and down from the boxes representing the magnitude of the maximum and minimum values.

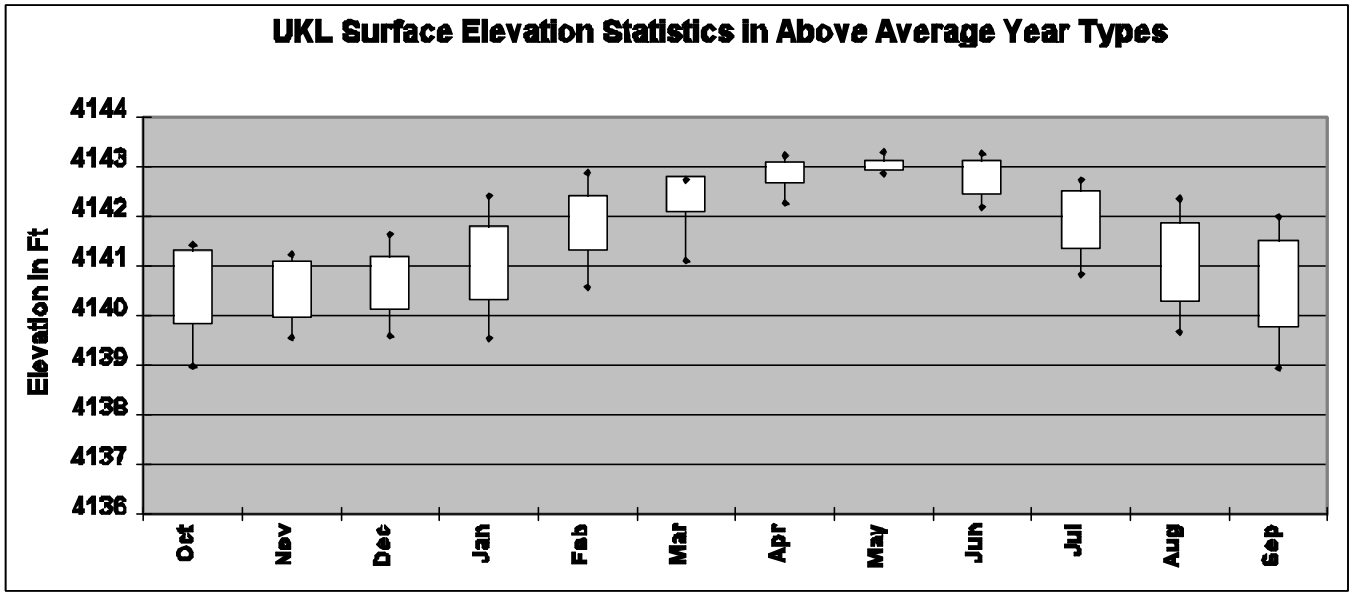
Table 4. End of the month Upper Klamath Lake elevations by water year type (1960-1998).

	20 Above Average Years				11 Below Average Years			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4141.41	4138.98	4140.57	0.73	4141.35	4138.36	4139.51	0.82
Nov	4141.23	4139.55	4140.53	0.56	4141.21	4138.99	4140.00	0.72
Dec	4141.63	4139.58	4140.64	0.52	4143.50	4138.80	4140.60	1.09
Jan	4142.40	4139.54	4141.05	0.75	4143.02	4139.41	4140.96	1.00
Feb	4142.87	4140.56	4141.86	0.55	4142.20	4140.15	4141.41	0.68
Mar	4142.73	4141.10	4142.43	0.36	4142.73	4141.35	4142.25	0.37
Apr	4143.21	4142.26	4142.86	0.21	4143.06	4142.15	4142.68	0.25
May	4143.29	4142.85	4143.03	0.10	4143.16	4142.22	4142.64	0.30
Jun	4143.25	4142.17	4142.78	0.34	4142.79	4141.30	4142.05	0.47
Jul	4142.73	4140.83	4141.93	0.59	4141.91	4140.00	4140.97	0.61
Aug	4142.34	4139.66	4141.07	0.78	4141.80	4138.85	4140.07	0.81
Sep	4141.98	4138.95	4140.63	0.86	4141.46	4138.18	4139.53	0.84
	5 Dry Years				**2 Critical Years**			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4139.60	4138.18	4138.66	0.50	4137.59	4136.93	4137.26	0.33
Nov	4140.50	4138.96	4139.78	0.51	4138.32	4137.80	4138.06	0.26
Dec	4141.81	4139.66	4140.70	0.72	4139.27	4138.58	4138.93	0.34
Jan	4141.54	4140.26	4141.12	0.46	4140.27	4140.01	4140.14	0.13
Feb	4142.38	4140.41	4141.62	0.67	4141.35	4140.94	4141.15	0.20
Mar	4142.84	4141.70	4142.42	0.43	4142.19	4141.80	4142.00	0.20
Apr	4142.95	4141.68	4142.44	0.49	4142.12	4141.68	4141.90	0.22
May	4142.85	4141.40	4142.43	0.54	4142.00	4140.70	4141.35	0.65
Jun	4142.45	4140.39	4141.63	0.71	4140.81	4139.45	4140.13	0.68
Jul	4140.86	4139.10	4140.21	0.63	4139.04	4138.77	4138.91	0.13
Aug	4139.78	4138.38	4139.11	0.50	4137.72	4137.52	4137.62	0.10
Sep	4139.45	4137.55	4138.49	0.62	4137.43	4136.84	4137.14	0.30

Above Average Year

Above average years occurred in 20 of the 38 hydrologic years utilized for this assessment (52.6%). The minimum elevation ranged from 4138.95 at the end of September to 4142.85 at the end of May. The average ranged from 4140.53 at the end of November to 4143.03 at the end of May (Table 4, Figure 1).

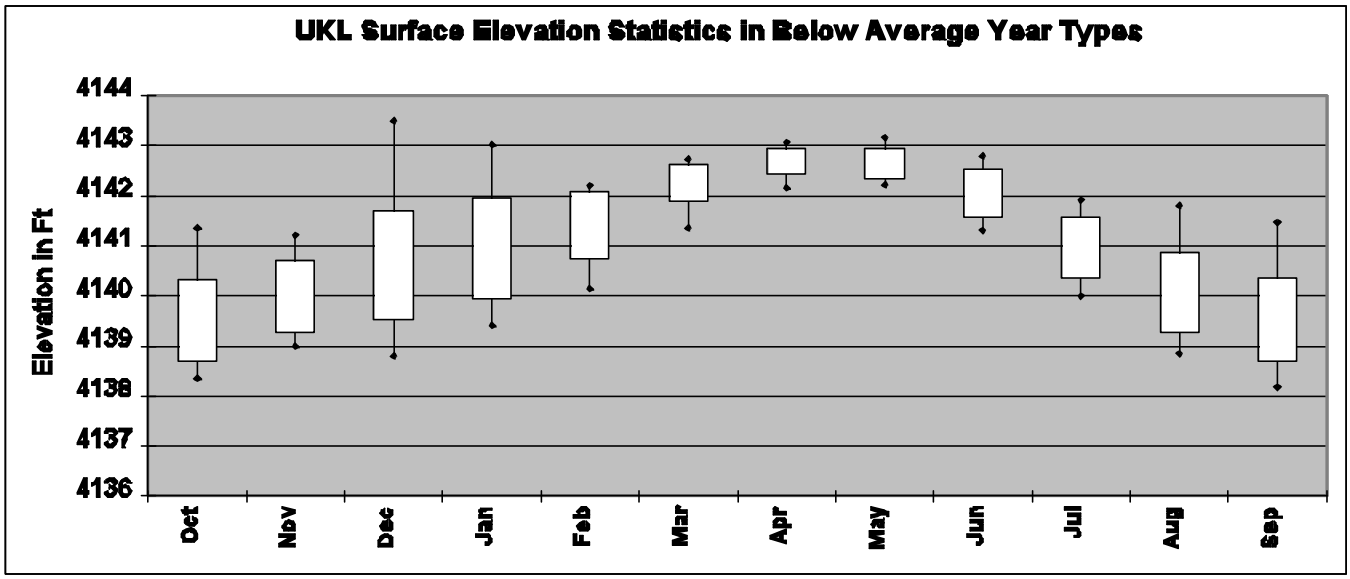
Figure 1. Upper Klamath Lake end of month elevations (1960-1998) for above average water years.



Below Average Year

Below average years occurred 11 of the 38 hydrologic years utilized for this assessment (28.9%). The minimum end of the month elevation ranged from 4138.18 in September to 4142.22 in May (Table 4, Figure 2). The average end of the month elevation ranged from 4139.51 in October to 4142.68 in April.

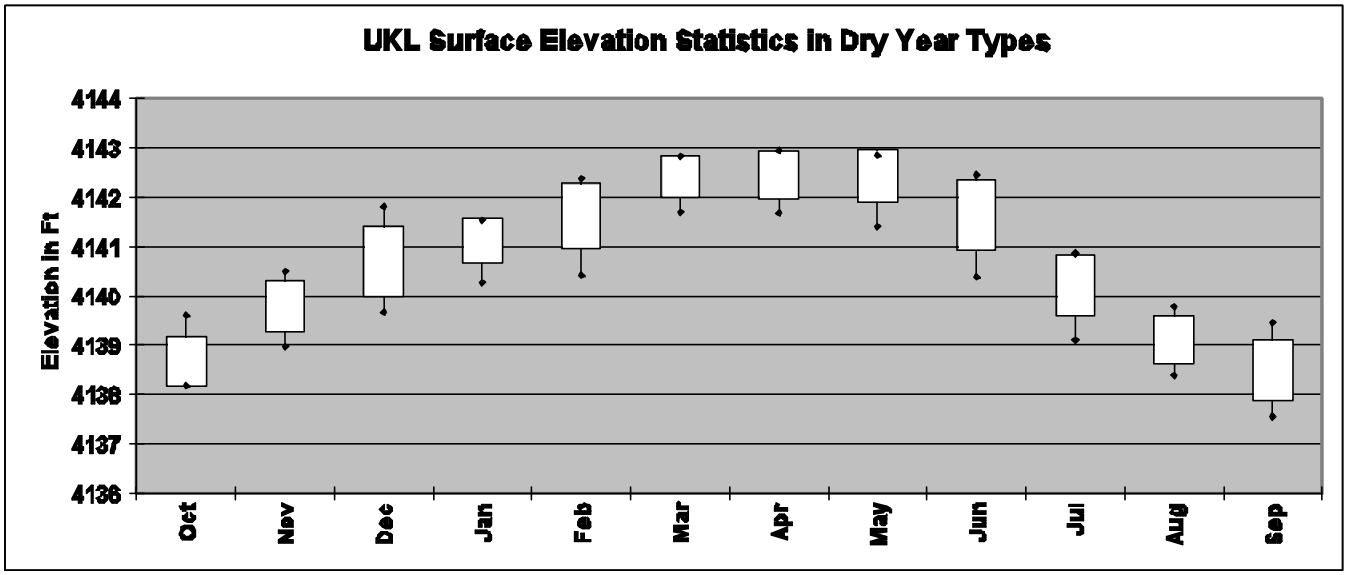
Figure 2. Upper Klamath Lake end of month elevations (1960-1998) for below average years.



Dry Year

Dry water years occurred 5 out of 38 hydrologic years utilized for this assessment (13.2%). The minimum end of the month elevation ranged from 4137.55 in September to 4141.70 in March (Table 4, Figure 3). The average end of the month elevation ranged from 4138.49 in September to 4142.44 in April.

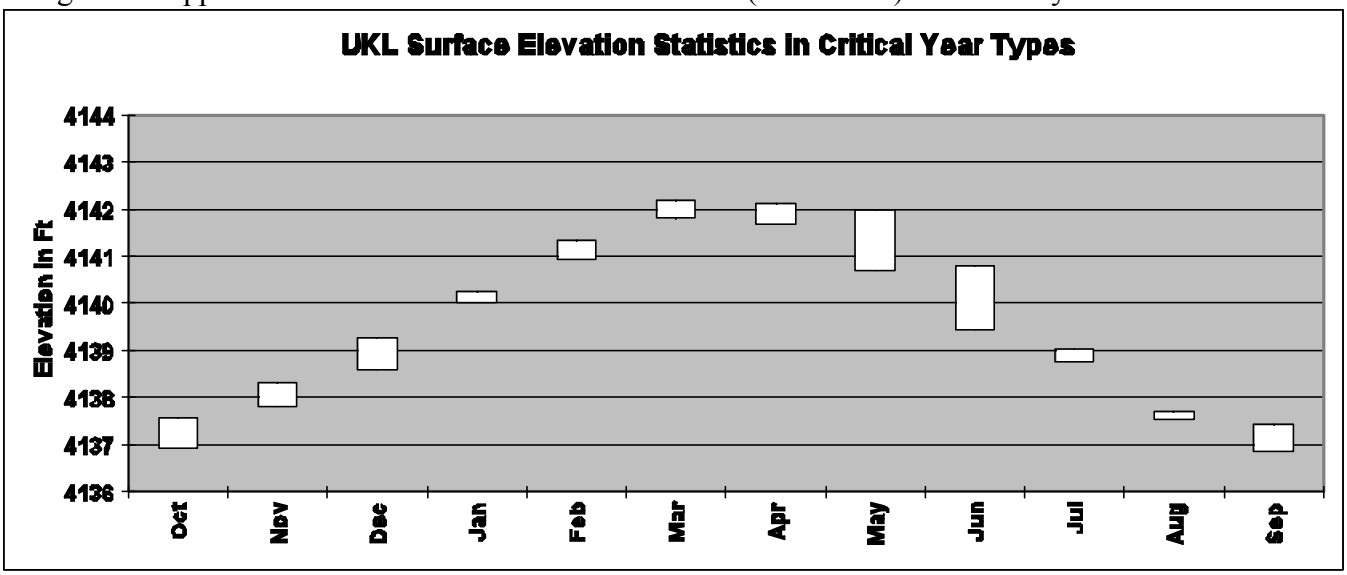
Figure 3. Upper Klamath Lake end of month elevations (1960-1998) for dry water years.



Critical Dry Year

Critical dry years occurred in 2 of the 38 hydrologic years utilized for this assessment (5.3%). The minimum end of month elevation ranged from 4136.84 in September to 4141.80 March (Table 4, Figure 4). The average end of the month elevation ranged from 4137.14 for September to 4142.00 for March.

Figure 4. Upper Klamath Lake end of month elevations (1960-1998) for critical years.



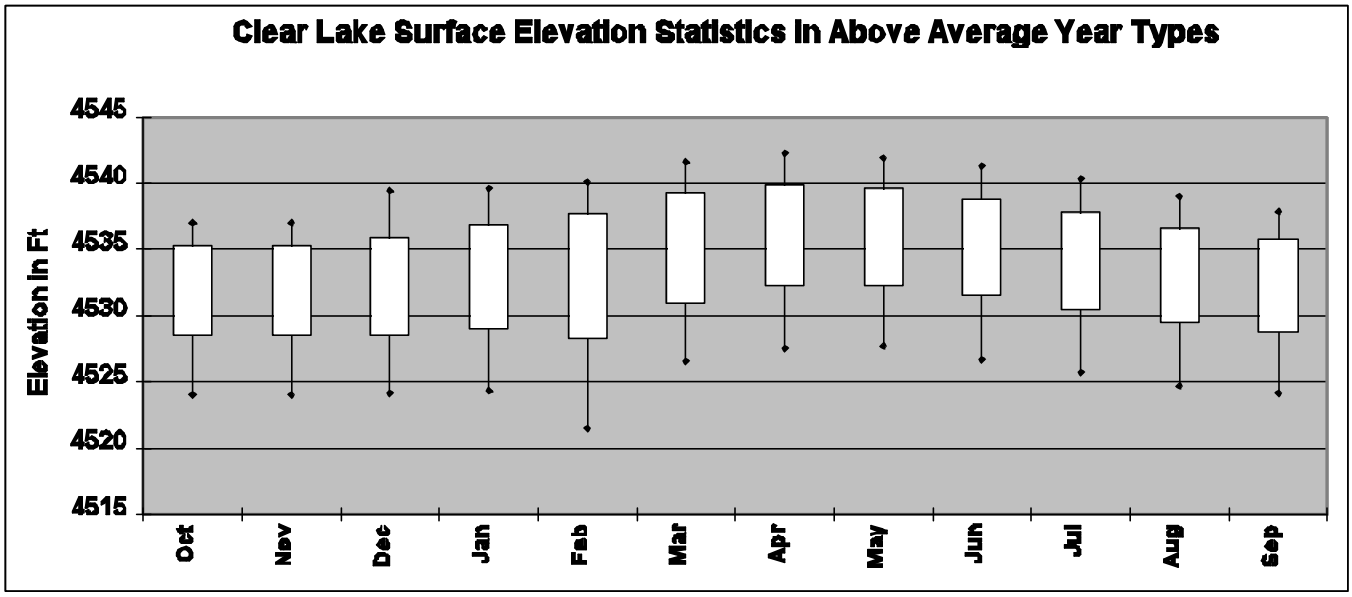
8.B.2. Clear Lake Reservoir. Statistics on historical water surface elevation data for water years 1961-1998 (October 1960-September 1998) are summarized by water year type in Table 5. Figures 5-8 provide a graphical presentation of these data.

Table 5. End of the month Clear Lake Reservoir elevations by water year type (1960-1998).

	20 Above Average Years				11 Below Average Years			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4537.02	4524.00	4531.90	3.37	4532.60	4521.33	4527.05	3.33
Nov	4537.05	4524.05	4531.87	3.41	4532.96	4521.47	4527.17	3.36
Dec	4539.43	4524.15	4532.21	3.70	4533.78	4521.70	4527.86	3.37
Jan	4539.60	4524.30	4532.93	3.98	4535.44	4521.87	4528.70	3.75
Feb	4540.11	4521.46	4532.97	4.68	4536.50	4523.37	4530.18	4.37
Mar	4541.63	4526.57	4535.07	4.21	4537.45	4524.25	4530.91	4.35
Apr	4542.28	4527.52	4536.08	3.80	4537.15	4525.50	4531.25	3.81
May	4541.89	4527.70	4535.91	3.67	4536.50	4525.10	4530.66	3.69
Jun	4541.27	4526.70	4535.16	3.68	4535.84	4524.08	4529.96	3.69
Jul	4540.33	4525.70	4534.14	3.66	4534.70	4522.88	4528.81	3.77
Aug	4538.97	4524.70	4533.08	3.57	4533.65	4521.90	4527.86	3.80
Sep	4537.86	4524.12	4532.29	3.49	4532.86	4521.28	4527.17	3.78
	5 Dry Years				**2 Critical Years**			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4528.30	4522.50	4525.38	1.91	4521.54	4519.30	4520.42	1.12
Nov	4528.30	4522.51	4525.71	1.85	4521.65	4519.29	4520.47	1.18
Dec	4528.48	4522.80	4526.60	2.05	4521.96	4519.35	4520.66	1.30
Jan	4529.02	4522.85	4527.45	2.32	4525.89	4519.40	4522.65	3.24
Feb	4532.00	4527.00	4529.45	1.83	4526.20	4523.00	4524.60	1.60
Mar	4532.68	4527.10	4529.85	1.87	4526.30	4522.84	4524.57	1.73
Apr	4532.54	4526.90	4529.59	1.83	4525.84	4522.75	4524.30	1.54
May	4532.18	4526.42	4529.14	1.87	4525.39	4521.77	4523.58	1.81
Jun	4531.20	4525.65	4528.28	1.81	4524.49	4521.18	4522.84	1.66
Jul	4530.20	4524.45	4527.11	1.87	4523.16	4520.44	4521.80	1.36
Aug	4529.13	4523.52	4526.18	1.86	4521.43	4519.82	4520.63	0.80
Sep	4528.30	4522.75	4525.52	1.88	4521.70	4519.42	4520.56	1.14

Above Average Year. The minimum end of the month elevation ranged from 4524.00 in October to 4527.70 in May (Table 5, Figure 5). The average end of the month elevation ranged from 4531.87 in November to 4536.08 in April.

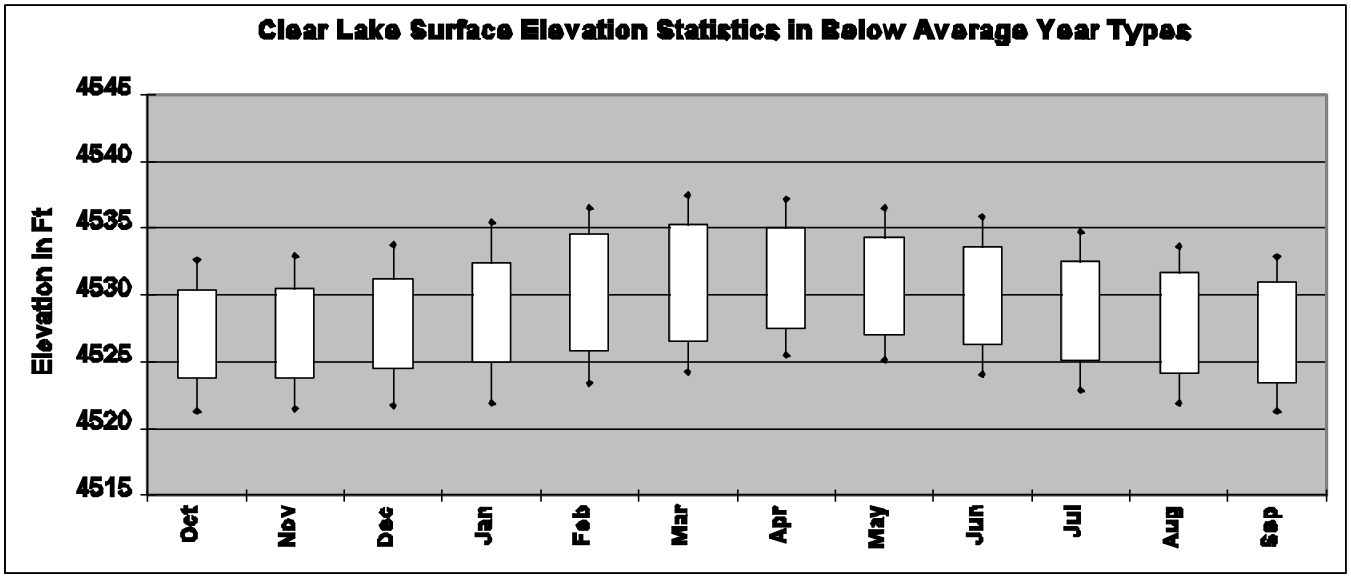
Figure 5. Clear Lake Reservoir end of month elevations (1960-1998) for above average years.



Below Average Year

The minimum end of the month elevation ranged from 4521.28 in September to 4525.50 in April (Table 5, Figure 6). The average end of the month elevation ranged from 4527.05 in October to 4531.25 in April.

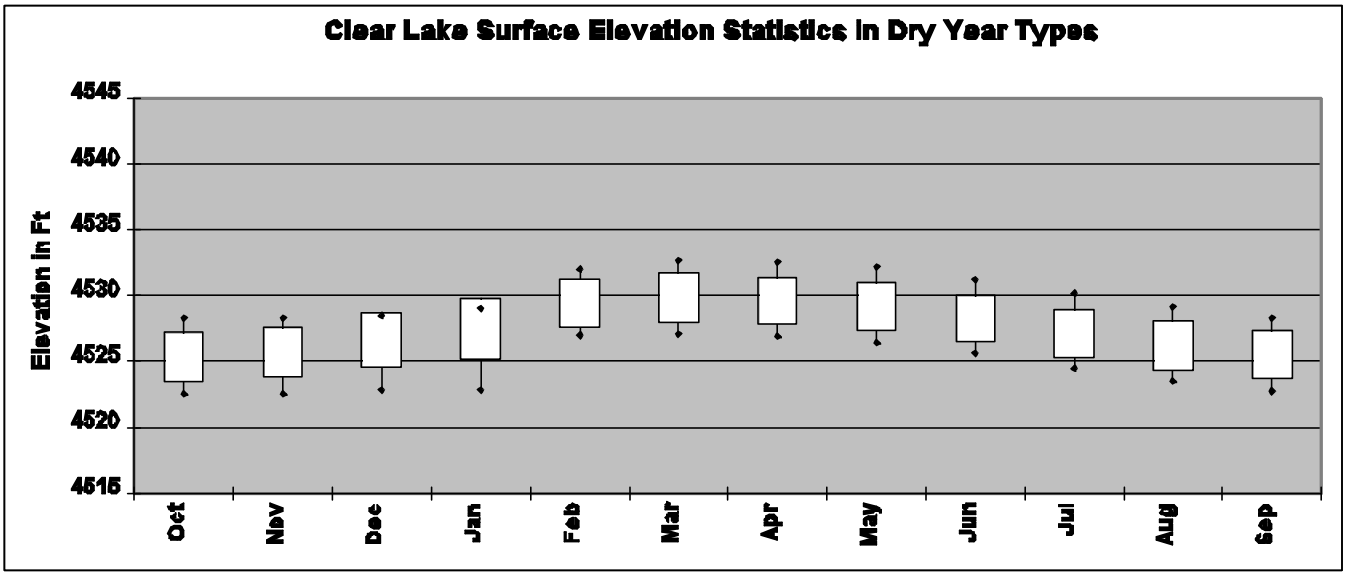
Figure 6. Clear Lake Reservoir end of month elevations (1960-1998) for below average years.



Dry Year

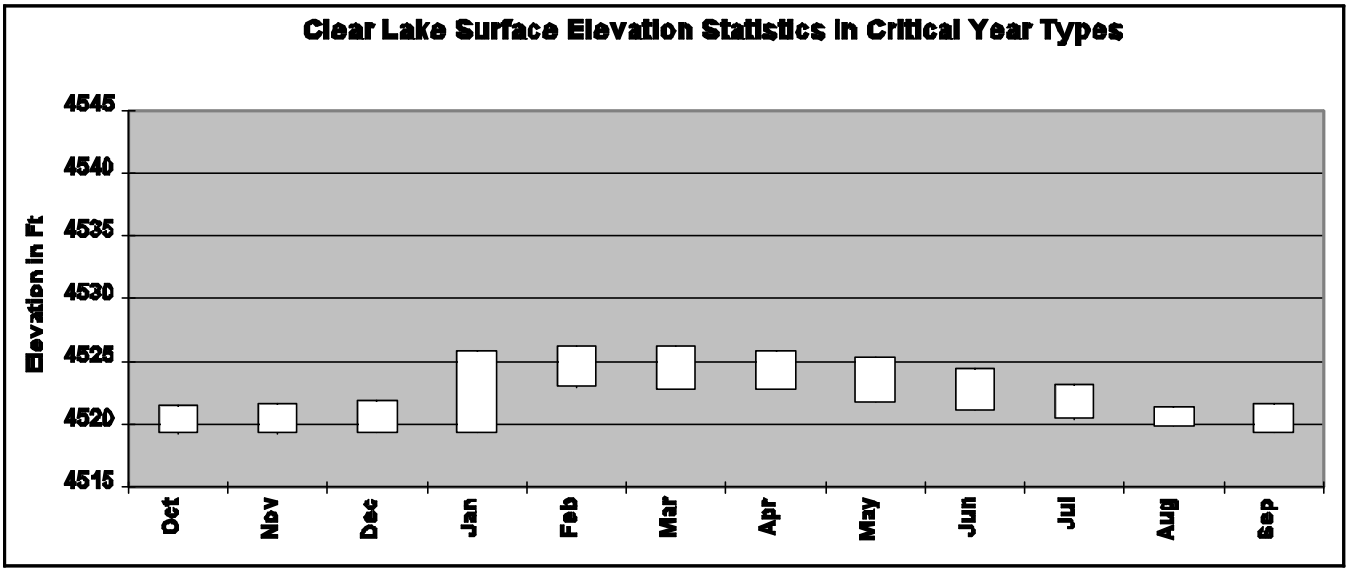
The minimum end of the month elevation ranged from 4522.50 in October to 4527.10 in March (Table 5, Figure 7). The average end of the month elevation ranged from 4525.38 in October to 4529.85 in March.

Figure 7. Clear Lake Reservoir end of month elevations (1960-1998) for dry years.



Critical Dry Year. The minimum end of the month elevation ranged from 4519.29 in November to 4523.00 in February (Table 5, Figure 8). The average end of the month elevation ranged from 4520.42 in October to 4524.60 in February.

Figure 8. Clear Lake Reservoir elevations (1960-1998) by month for critical dry years.



8.B.3. Gerber Reservoir. Statistics on Gerber Reservoir historical water surface elevation data for water years 1961-1998 (October 1960-September 30, 1998) are summarized by water year type in Table 6.

Table 6. End of the month Gerber Reservoir elevations by water year type (1960-1998).

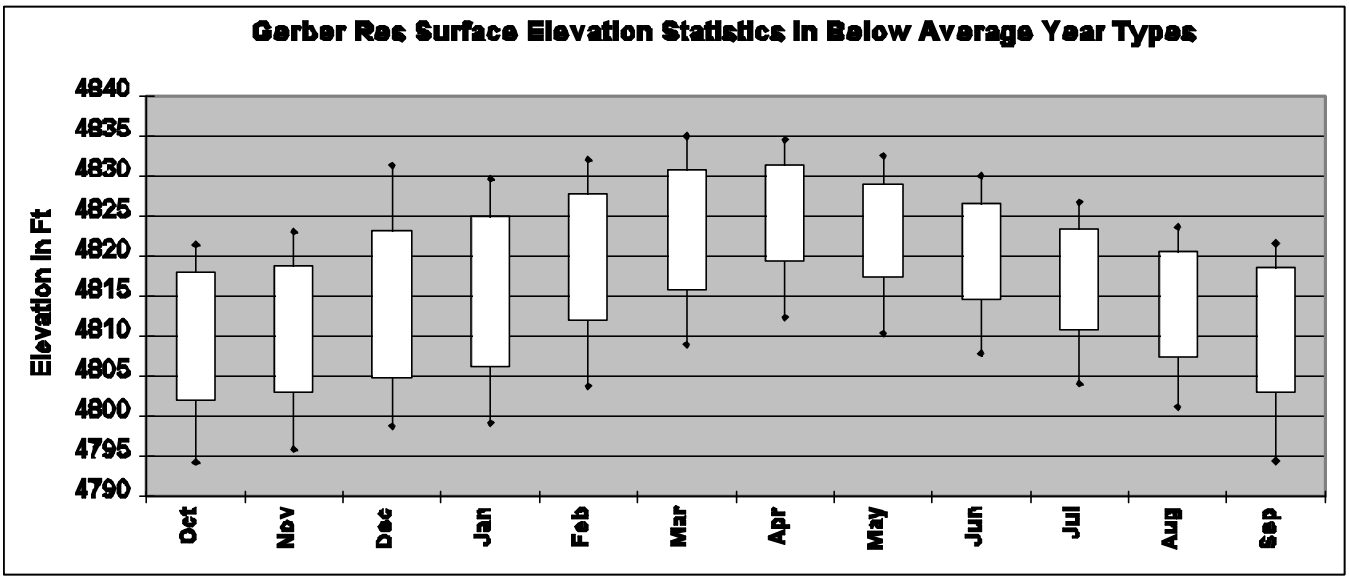
	29 Above Average Years				11 Below Average Years			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4826.26	4815.18	4822.38	3.32	4821.49	4794.27	4810.89	8.09
Nov	4828.12	4815.10	4822.54	3.55	4823.04	4795.93	4810.89	7.91
Dec	4834.60	4815.20	4823.50	4.49	4831.40	4798.80	4814.01	9.16
Jan	4834.18	4816.58	4824.79	4.94	4829.70	4799.14	4815.54	9.37
Feb	4835.04	4802.24	4825.11	9.14	4832.03	4803.80	4819.94	7.85
Mar	4836.19	4821.30	4831.21	5.00	4835.00	4809.00	4823.32	7.49
Apr	4836.48	4827.30	4833.75	2.85	4834.59	4812.37	4825.40	5.94
May	4836.29	4827.00	4832.83	2.71	4832.57	4810.35	4823.20	5.75
Jun	4835.16	4824.10	4830.66	2.99	4830.03	4807.88	4820.67	6.04
Jul	4832.68	4820.81	4827.80	3.19	4826.78	4804.13	4817.16	6.33
Aug	4830.39	4817.98	4825.00	3.34	4823.64	4801.24	4814.01	6.61
Sep	4828.00	4815.26	4822.76	3.39	4821.63	4794.47	4810.77	7.86

	5 Dry Years				2 Critical Years			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4809.26	4797.98	4803.23	3.64	4806.39	4796.62	4801.61	4.99
Nov	4811.50	4797.90	4805.52	4.78	4806.74	4796.62	4801.68	5.06
Dec	4821.60	4798.04	4808.91	7.84	4807.08	4797.06	4802.07	5.01
Jan	4822.20	4798.18	4811.02	8.61	4816.63	4798.79	4807.71	8.92
Feb	4825.65	4804.52	4816.35	6.69	4822.94	4800.74	4811.84	11.10
Mar	4825.91	4804.18	4817.55	7.24	4823.30	4801.28	4812.29	11.01
Apr	4824.71	4808.26	4818.08	5.58	4822.48	4801.14	4811.81	10.67
May	4822.84	4808.10	4816.55	4.91	4820.80	4798.86	4809.83	10.97
Jun	4819.52	4803.60	4813.29	5.39	4817.81	4798.36	4808.09	9.73
Jul	4815.48	4799.22	4809.19	5.55	4814.08	4797.73	4805.91	8.18
Aug	4812.90	4798.60	4806.10	4.79	4810.16	4797.01	4803.59	6.57
Sep	4809.64	4798.08	4803.37	3.74	4806.78	4796.52	4801.65	5.13

Above Average Year

The minimum end of the month elevation ranged from 4802.24 in February to 4827.30 in April (Table 6, Figure 9). The average end of the month elevation ranged from 4826.26 in October to 4836.48 in April.

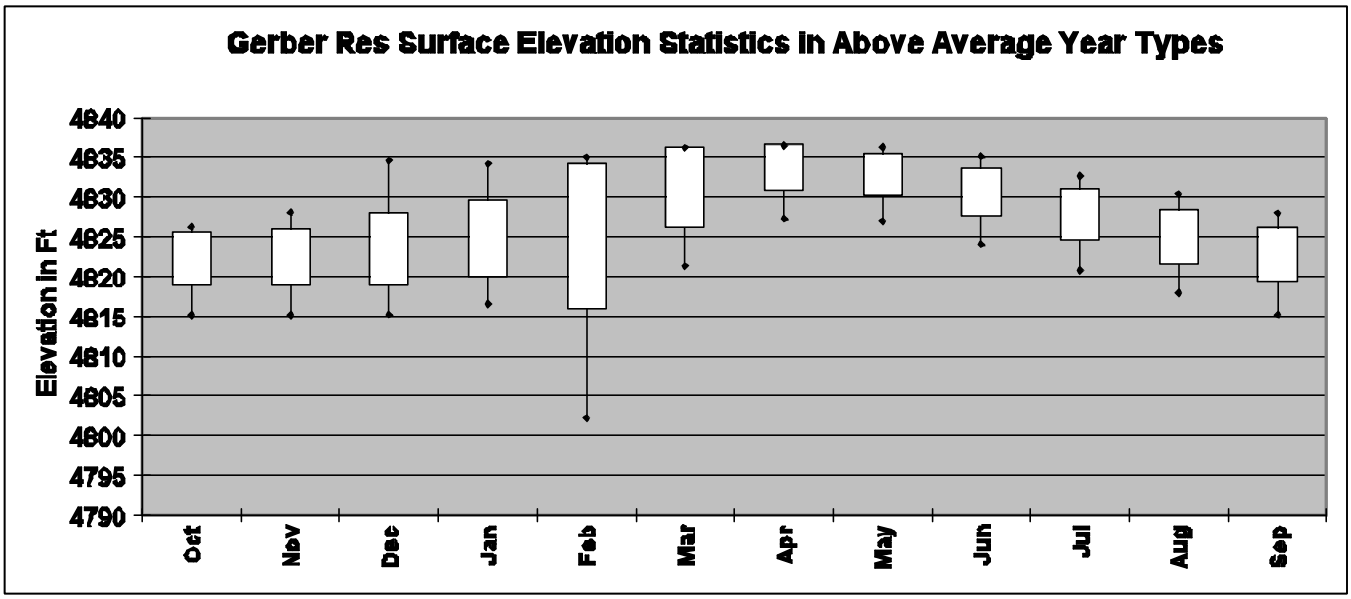
Figure 9. Gerber Reservoir end of month elevations (1960-1998) for above average years.



Below Average Year

The minimum end of the month elevation ranged from 4794.27 in October to 4812.37 in April (Table 6, Figure 10). The average end of the month elevation ranged from 4810.09 in October to 4825.40 in April.

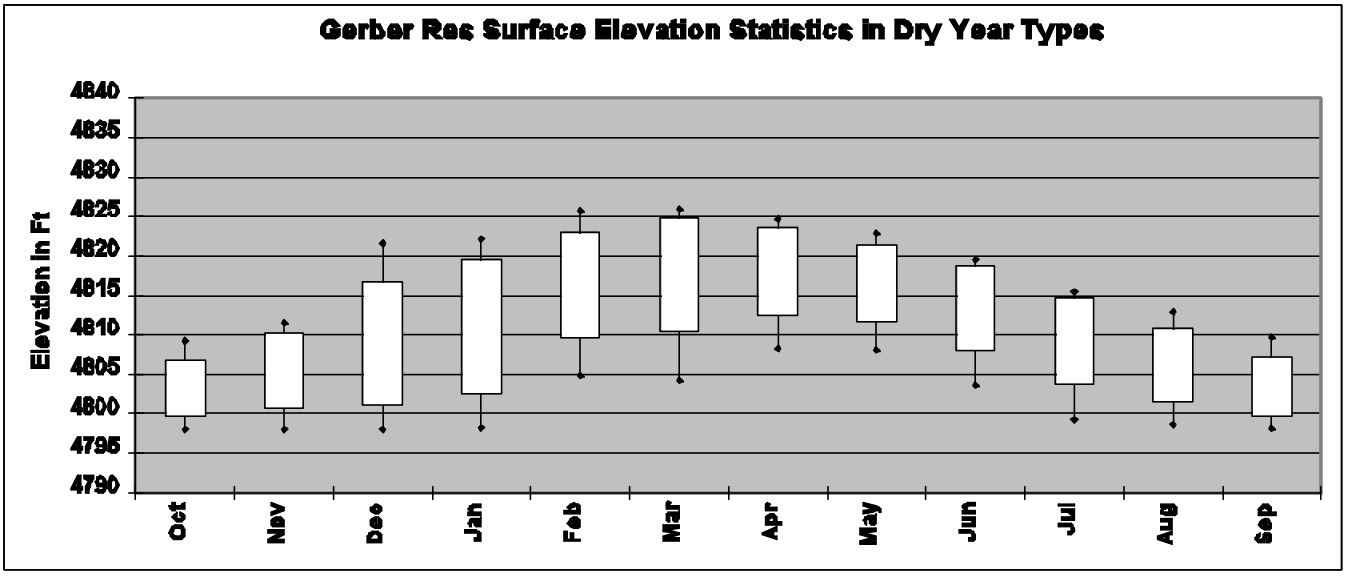
Figure 10. Gerber Reservoir end of month elevations (1960-1998) for below average years.



Dry Year

The minimum end of the month elevation ranged from 4797.98 in October to 4808.26 April (Table 6, Figure 11). The average end of the month elevation ranged from 4803.25 in October to 4818.08 in April.

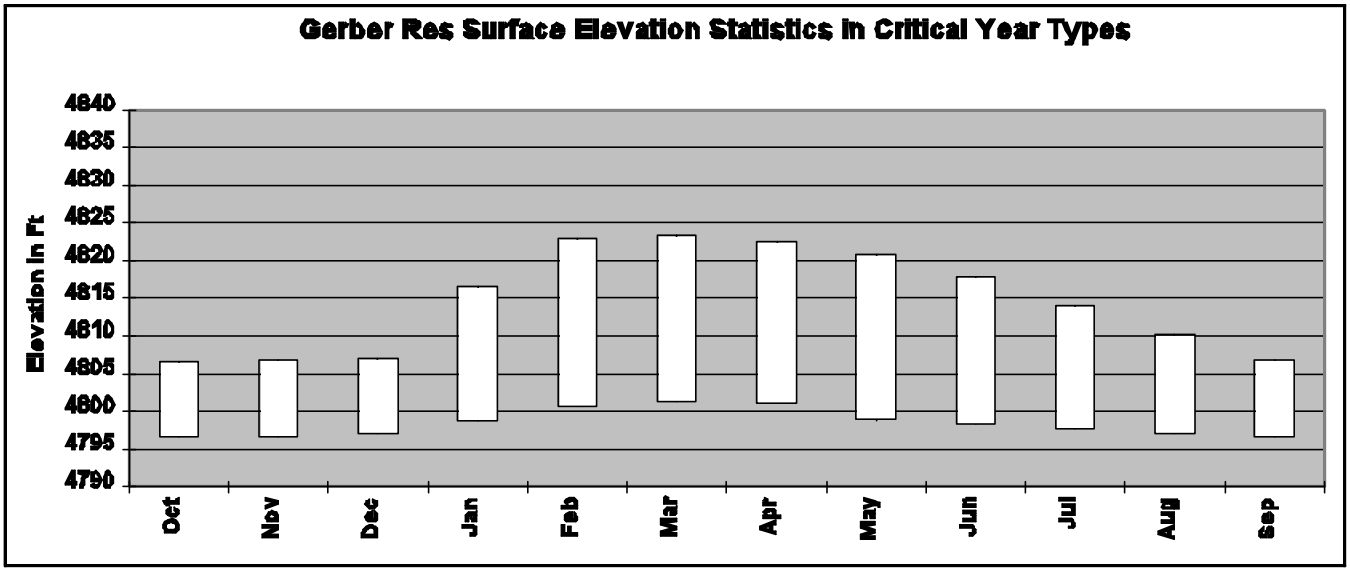
Figure 11. Gerber Reservoir end of month elevations (1960-1998) for dry years.



Critical Dry Year

The minimum end of the month elevation ranged from 4796.52 in September to 4801.28 in March (Table 6, Figure 12). The average end of the month elevation ranged from 4801.61 in October to 4812.29 in March.

Figure 12. Gerber Reservoir end of month elevations (1960-1998) for critical dry years.



8.B.4. Agricultural and Refuge Water Use. Water is diverted from Project storage facilities to provide for crop production and needs on National Wildlife Refuges located within the Project service area (Table 7).

Table 7. Crop and refuge water use from Upper Klamath Lake (1961 through 1999–values in 1,000s of acre-feet).

	19 Above Average Years			11 Below Average Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	28.9	6.58	17.78	27.77	12.34	18.53
November	15.86	.49	6.78	14.25	2.28	6.81
December	17.28	.39	8.68	16.43	1.52	8.5
January	22.74	5.43	12.43	23.57	6.24	13.79
February	17.64	2.33	7.28	11.10	2.94	8.03
March	12.87	.3	4.69	10.68	1	6.07
April	52.85	5.49	21.14	52.85	21.92	36.17
May	76.70	28.95	55.15	81.83	50.55	65.49
June	103.54	45.33	81.72	102.05	73.11	86.17
July	105.38	75.33	91.35	104.55	75.37	93.25
August	87.20	47.71	74.63	88.58	36.08	71.50
September	61.45	34.63	48.09	60.95	40.15	48.76

	5 Dry Years			2 Critical Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	29.13	8.83	20.50	31.17	14.62	22.90
November	16.52	1.5	6.15	9.51	5.57	7.54
December	17.09	6.15	11.99	20.33	15.26	17.80
January	20.67	9.33	13.72	19.70	11.14	15.42
February	12.12	2.23	7.27	12.60	7.35	9.98
March	17.99	1.75	10.15	16.30	11.07	13.69
April	67.32	27.11	41.53	63.63	57.64	60.64
May	58.73	37.60	50.47	90.12	51.50	70.81
June	91.75	70.99	81.70	87.66	78.67	83.17
July	99.81	87.40	95.28	103.77	58.25	81.01
August	83.48	76.26	79.37	90.84	64.91	77.88
September	66.07	49.63	58.56	33.46	32.15	32.81

8.C. Project Facilities and Operations

1. Gerber Dam and Reservoir

Gerber Dam is located on Miller Creek about 14 miles east of Bonanza, Oregon. Gerber Reservoir has a surface area of 3830 acres and an active capacity of 94,270 acre feet at the spillway crest, elevation 4835.4 feet. The dam is a variable radius, thin arch concrete dam, with a structural height of 88.0 feet and a crest length of 485 feet. The elevation of the top of the dam is 4841.9 feet, and the elevation of the top of the 3.5-foot parapet wall is 4845.4 feet. The arch thickness at the crest is 5 feet and at the base 17.85 feet.

Construction of Gerber Dam was completed in May of 1925. The reservoir is used to store seasonal runoff to meet irrigation needs of the Project, primarilly for the Langell Valley Irrigation District (LVID), and to limit runoff into Tule Lake.

The spillway is located in the center of the dam and consists of an uncontrolled overflow crest with a length of 150 feet and a crest elevation of 4835.4 feet. The spillway has a capacity of 17,500 cfs at elevation 4845.4 feet (top of the parapets). The spillway discharge falls into a plunge pool in which the water surface is maintained by a riprap weir.

The outlet works consists of three, 36-inch-diameter, cast iron conduits about 15 feet long installed through the base of the dam. The conduits have trash-racked bellmouth intakes with a downstream transition into the rectangular gate section. Releases are controlled at the downstream end of the outlet works by three, 2-foot 6-inch by 2-foot 6-inch, cast iron, manually operated high-pressure gates. The high-pressure gates are enclosed in a concrete control house which was built as an integral part of the downstream face of the dam. The centerline elevation of the control gates is 4775.0 feet. The outlet gates are normally submerged and discharge directly into the spillway plunge pool. The maximum combined design capacity of the three outlet conduits is about 900 cfs when the reservoir level is near the dam crest (USBR Web).

Prior to the construction of the dam, no reservoir existed and Miller Creek would run dry from June to October in most years.

The outlet at Gerber is opened in the spring (approximately April 15) to provide irrigation water to the LVID lands. The outlets would normally be shut off on October 1. To prevent freezing of the outlet valves during the winter approximately one cubic foot per second is bypassed and released into the Miller Creek channel. The bypass usually begins in November and continues to the beginning of the irrigation season.

During the irrigation season the outlets are operated on demand of LVID. Maximum flows recently experienced are in the 170 cfs range. LVID operates the dam during the irrigation season under a purchase order type agreement for Reclamation. During the fall and winter Reclamation operates the dam. During the spring the dam is operated to provide the maximum amount of storage possible and still provide flood protection to the Tule Lake lands. There is no attendant at the dam during the year, although past experience shows that the dam is visited by the district at least twice a week to make gate changes and record readings. Studies completed by Reclamation[1] indicate that with a recurrence of the 1924-34 drought, deficiencies approaching 80 to 95 percent would occur. During the 1991 irrigation season the reservoir release was stopped in early July due to the lack of inflow that spring.

The entire Gerber watershed was surveyed by Reclamation in 1970 to summarize available data on the use of water above the Dam (USBR 2000).

2. North Canal (Langell Valley Irrigation District)

Constructed in 1918, a small earth channel structure 20 ft wide x 4 ft deep x 6 miles long with a stop log diversion structure is located on Miller Creek approximately six miles below Gerber Dam. The North Canal, operated by Langell Valley Irrigation District, carries all irrigation water released from Gerber Dam to lands within Langell Valley Irrigation District. Maximum out flow is approximately 200 cfs.

No water is released to Miller Creek below the structure, although return flows from irrigation of adjacent lands provide some inflow.

The canal is operated in response to crop demand, generally beginning in April. At the end of the irrigation season (October), the canal is drained and the water returned to the Lost River. The entire supply of water for this canal comes from Gerber Reservoir. During 1991, the district maintained a minimum pool for fish and eagles in Gerber, thereby necessitating the cessation of irrigation flows during mid-July.

During the non-irrigation season the stoplogs in the structure are removed allowing free passage of flow down Miller Creek (USBR 1992a).

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[1] Upper Lost River Division, Concluding report on possibilities for water resource development and a supplemental water supply for Langell Valley, Bureau of Reclamation, June 1972.

3. Clear Lake Dam and Reservoir

Clear Lake Dam is located in California on the Lost River about 39 miles southeast of Klamath Falls, Oregon, and provides storage for irrigation and reduced flow into the reclaimed portion of Tule Lake and the restricted Tule Lake Sumps in Tulelake National Wildlife Refuge The dam is an earth and rockfill structure with a crest length of 840 feet and a height of 36 feet above the streambed. The crest of the dam is at elevation 4,552.0 feet and is 20 feet wide. At the normal maximum water surface elevation of 4,543.0 feet, the dam will impound a total of 527,000 acre-feet in Clear Lake Reservoir. Clear Lake has earthen Dikes which are located at the south end of Clear Lake and provide protection to the Tulelake homesteaded lands. There are two dikes that are interconnected and are both earth core and rip-rap protected. The Main dike runs east and west and was constructed when the stop logs were placed in the spillway in the late 1930's. The South Dike runs southeast and was constructed in 1974 when the spillway was raised permanently. The dikes do not become operative until surcharge on the reservoir is reached.

The spillway structure consists of a concrete overflow weir and side channel located at the left abutment of the dam. With a crest elevation of 4,543.0 feet, the overflow weir is 357 feet in length and has a rated capacity of 5,650 cfs at 2.7 foot depth of flow (Water Surface Elevation 4,545.7 ft). The spillway was reconstructed in 1974.

The Outlet works consist of an Outlet Tunnel comprised of two 53" high x 4'0" wide outlet tubes which extend from the base of the outlet control structure at the upstream face of the dam, to a point approximately 31 feet downstream where they merge into one 7 ft x 7 ft arched outlet tunnel. Two screw-lift outlet gates are located in the outlet control structure, each 4 ft wide by 4'9" high. Each gate is raised and lowered by a hand-cranked screw-lift assembly. A portable power unit is available to power the gate mechanism (USBR Web).

Prior to the construction of the dam a natural lake and marsh/meadow existed. The meadow was seasonally farmed by the Carr Livestock Company. During most years the Lost River below the present dam would run dry from June through October. Historic elevations are included in the appendix.

The outlet at Clear Lake is opened in the spring, usually around April 15, to provide irrigation water to LVID, Horsefly Irrigation District (HID) and private "Warren Act" contract lands. In most years the outlets are shut off around October 1. No other releases are made from the dam unless an emergency condition dictates otherwise. Since the reservoir has a storage limitation of 350,000 acre-feet from October 1 through March 1, summer drawdown releases are occassionally necessary.

A purchase order is issued each year that permits LVID to operate the dam on a reimbursable basis. LVID operates the gates and reports the changes to Reclamation on a daily basis. Flow changes are dictated by the needs of HID and LVID and the private users along the Lost River. During the non-irrigation season Reclamation operates the dam and reservoir. The reservoir is managed to store as much water as possible without encroaching on the operational guidelines. The target elevation after March 1 is 4537.4. Should inflow cause this elevation to be exceeded the water must be released in a timely manner until that elevation is reached. During the irrigation season the dam is visited approximately twice a week and, during the winter, once a month.

During 1970 a careful review and survey of all the water impoundments above the dam was made. This report[2] summarized pertinent facts about private and Federal storage dams and water spreading operations in the watershed (USBR 1992a).

During the history of the reservoir the level has been below elevation 4,522.0 ten years during the fall and winter months. Fall elevations and years in which they occurred are as follows:

Date	Elevation	Date	Elevation
1930	4,521.84	1935	4,518.60
1931	4,517.20	1936	4,521.15
1932	4,519.84	1937	4,521.60
1933	4,517.70	1961	4,521.28
1934	4,514.50	1962	4,521.44

4. Malone Diversion Dam

Constructed in 1923, the Malone Diversion Dam is located approximately eleven miles below Clear Lake Dam on the Lost River. The purpose of the dam, operated by LVID pursuant to Bureau supervision, is to divert water released from Clear Lake into the West Canal and the East Malone Lateral for irrigation in the LVID.

The dam, an earth embankment wing with a concrete gate structure, has a spillway elevation crest of 4,158 and total usable capacity of approximately 500 acre-feet. Normal irrigation releases into the west canal are 130 cfs, and 30 cfs into the east Malone Lateral.

When LVID begins receiving orders for irrigation deliveries from areas served by the West Canal and the East Malone Lateral, the radial gates are lowered to fill the reservoir. The reservoir water surface is maintained at or near 10.0 feet above the gate sill. The West and East Malone Canals are regulated at the dam. At the end of the irrigation season, the radial gates are raised to allow for passage of flood waters during the winter and spring.

5. West Canal (Langell Valley Irrigation District)

The West Canal headworks are located at Malone Dam on the Lost River approximately ten miles below Clear Lake. Water is released at Clear Lake and then diverted by Malone Dam into the West Canal. The West Canal, operated by LVID, supplies irrigation water to over 17,000 acres of land located in two irrigation districts (Horsefly ID and Langell Valley ID).

The West Canal is an earthen channel 20 ft wide x 4 ft deep x 10 miles long that was constructed in 1918. Maximum outflow is 200± cfs.

The canal is operated in response to crop demand. At the end of the irrigation season, the canal is drained into the Lost River. The entire supply of water for this canal comes from Clear Lake Reservoir (USBR 1992a).

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[2] Klamath Project, Clear Lake Watershed Report, Water Rights Engineering Branch-Sacramento, June 1970.

6. Wilson Diversion Dam & Reservoir (Lost River Diversion Dam)

Wilson Diversion Dam, a concrete multiple arch with earth enbankment wings, was constructed in 1912, approximately eight miles southeast of Klamath Falls on the Lost River. It is operated by Reclamation for the purpose of diverting water from the Lost River into the Klamath River for irrigation and flood control.

The dam with a spillway crest elevation of 4094.5 creates an impoundment with a surface area of 340 acres and 2,300 acre feet of storage. Inflows are dependant on Lost River Flows. Maximum Release to the Diversion Channel is 3,000 cfs.

Operation. The dam is operated primarily as a diversion dam, diverting Lost River flows into the Diversion Channel and thence to the Klamath River. During the irrigation season the water surface behind the dam is raised slightly to facilitate irrigation pumping from the reservoir. During the winter and spring the reservoir is lowered to provide a cushion for high flow conditions. The dam is able to divert a maximum of 3,000 cfs of Lost River flows into the Diversion Channel and must spill any flows above that amount into the Lost River below the dam.

7. Lost River Diversion Channel

The Diversion Channel, operated by Reclamation begins at Wilson Diversion Dam and travels in a westerly direction, terminating at the Klamath River. It was constructed originally in 1912 and enlarged in 1948. It is an earthen channel 8 miles long. The channel is capable of carrying 3,000 cfs to the Klamath River from the Lost River system during periods of high flow. The channel is designed so that water can flow in either direction depending on operational requirements. During the irrigation season the predominant direction of flow is from the Klamath River. Miller Hill Pumping Plant is located on the channel along with the Station 48 drop to the Lost River system.

Operation. During the fall, winter, and spring, the channel is operated so that all of the water that enters from the Lost River is bypassed to the Klamath River. During periods that the flow is in excess of 3,000 cfs water is bypassed into the Lost River. During the spring of most years it is necessary to import water from the Klamath River to the Lost River for early irrigation in the Tule Lake area. During the summer months the channel is operated as if it were a forebay for the Miller Hill Pumping Plants (see below) and the Station 48 turnout (see below). Depending on the needs of these two irrigation diversions, water that is not able to come from the Lost River must come from the Klamath River.

If necessary Reclamation can isolate the diversion channel from both the Lost River and the Klamath River for emergency and maintenance activities. During normal operations, water levels in the channel are maintained at or near the levels in the Klamath River.

8. Miller Hill Pumping Plant (Lost River Diversion Channel)

Miller Hill pumping plant constructed in 1941 has three 35 cfs concrete base interior design pumps units (105 cfs maximum flow) that lift water from the Diversion Channel into the C-4-e lateral (see the Lost River Diversion Channel) for irrigation use. The pumping plant is operated by Klamath Irrigation District pursuant to a Joint Liability type contract with Reclamation.

Operation. The pumps are operated on demand of the irrigators that take water from the C-4-e system. The pumps are not used during the non-irrigation season.

9. Station 48 Turnout (Lost River Diversion Channel)

Station 48, a concrete box culvert with slide gates was constructed in 1948, is a turnout located on the south bank of the Lost River Diversion Channel. Maximum flows are 550 cfs. The discharge from the turnout enters a short channel and then enters the Lost River. The turnout is operated, pursuant to a Purchase Order, by radio telemetry from the Tulelake Irrigation District (TID) Headquarters.

Operations. Tulelake Irrigation District operates the Station 48 gates to provide the required flow into the J-Canal located at Anderson-Rose Diversion Dam (see Anderson-Rose details). TID must estimate the amount of return flows to the Lost River between Station 48 and the headworks of the J-Canal and then adjust Station 48 to provide for the J-Canal needs. If the amount of water released is too high, the excess is spilled into the Lower Lost River below the Anderson-Rose dam.

Gates are normally opened from the first of March until mid-November. From 12 to 36 hours are normally required for water from Station 48 to reach Anderson-Rose Dam. It is difficult to determine the amount of water required at the dam due to unknown quantities of return flow between Station 48 and Anderson Rose Dam, and also the time lag between diversions at Station 48 and the dam. USBR 1992a)

10. Anderson-Rose Diversion Dam (J-Canal Headworks)

Anderson-Rose Dam was constructed in 1921 by the Reclamation to provide the necessary forebay for the J-Canal headworks located on the left abutment of the dam. The J-Canal is the main distribution canal for the Tulelake Irrigation District (TID).

The Anderson-Rose Dam is a reinforced concrete slab and buttress with a concrete overflow spillway and gate structure. It has a spillway height of 12 feet and length of 204 ft and two outlet gates into the Lost River. In addition, the headworks for the J-Canal are located on the left abutment of the dam. The dam ,operated by Tule Lake Irrigation District (TID) pursuant to Joint Liability type contract, is located on the Lost River in Oregon. In flows are dependent on releases from Station 48 and irrigation return flows. Maximum Diversion is 800 cfs with approximately 135,000 acre feet per year diverted to the J-Canal.

Operation. During the irrigation season the elevation of the Lost River is maintained at or very near the spillway crest. This provides for a maximum head for the J-Canal intake structure. Releases are carefully controlled from Station 48, located approximately ten miles above the dam, via telemetry to coincide with return flows accruing to the Lost River and irrigation demands of TID (J-Canal) to minimize potential spills below the dam. Occasionally operational spills do occur because of the time lag between Station 48 and the dam and the fact that returns to the river are not pre-measured.

Anderson-Rose Dam is the main source of water diversions for Tulelake Irrigation District, with the average of 135,000 acre feet per year diverted to the J-Canal. Other sources of water inflow to TID include return flows from the Klamath Irrigation District. Water in the system is eventually diverted onto individual farm units, either privately owned land or leased land within the Tule Lake National Wildlife Refuge (16,925 acres of irrigated land lie within the refuge).

There are currently 37 pumping plants with a total of 69 pumps within TID. Capacity of these pumps range from a low of 2 cfs to a high of 300 cfs. Irrigation in the district normally starts around March 1 and continues through mid-November. Return flow from fields eventually flow to the Tulelake Sumps. Average operations of TID are as follows: Station 48 to the Lost River = 60,000 AF; diverted at Anderson Rose Dam = 135,000 AF; diversions within the system = 250,000 AF; Pumping Plant D volume = 100,000 AF. (USBR 1992a)

11. Pumping Plant D (Tule Lake Sumps)

Pumping Plant D, constructed in 1941 and enlarged in 1949, removes excess water from the Tule Lake Sumps and discharges it into the P-Canal System. It is operated by the by Tulelake Irrigation District pursuant to a Joint Liability type contract with Reclamation. This is the only outlet point from the sump area. The low speed interior design turbine pumps, five pumps with a combined total of 3,650 horsepower turbine are housed in a concrete building within the Tule Lake National Wildlife Refuge. Maximum flow is 300 ft/sec with total annual pumpage ranges from a low of 50,000 AF to a high of 143,000 AF, averaging 91,000 AF.

Operation. The sumps act as a natural collection area for drainage return flows from Project lands. A portion of water is then removed from the sumps and used to irrigate the reserved sump lease lands and wildlife lands within the Refuge and then returned to the sumps by pumping. A considerable area within the sumps has become a decadent marsh due to low water depths caused by siltation.

12. Tule Lake Sump Area

The Tule Lake Sumps are operated by Tulelake Irrigation District pursuant to a Joint Liability type contract with Reclamation. Earthen dikes surround the 12,500 acre sumps, approximately 4 feet deep, which stores approximately 54,000 AF. The primary purpose of the sump area was originally for flood control.

Operation. The pump(s) are operated to maintain certain objective levels on the Tule Lake Sumps. These objective level were set by the U.S. Fish and Wildlife Service to facilitate hunting and waterfowl production and by Reclamation to protect the Tule Lake area from flooding and the reserved sumps that are leased by Reclamation. Occasionally the pumps are operated to provide irrigation water to the lands that are dependent on the P-Canal system (see above), including both Federal and private lands. Water from D Plant is the only source of irrigation water for some private lands and part of the Lower Klamath National Wildlife Refuge.

Considerable maintenance of the pumping plant is required during the time of the year that it is operated. Of particular concern is the need to remove great quantities of weeds that collect on the trashracks in front of the pumps.

13. P-Canal System

Constructed in 1942, the P-Canal system, consisting of the Tule Lake Tunnel Outlet Canal, and the P, P-1, and P-1-a Canals, conveys the water discharged from the Tule Lake Tunnel to wetlands located within the Lower Klamath National Wildlife Refuge. In addition, water is conveyed to Federal leased lands in the lower Klamath area and to private land owners under surplus water rental agreements (see water rentals). The canal system is operated by Reclamation.

The 15 miles of unlined earth canals are up to 25 feet in width and vary in depth up to 5 feet. Maximum flow in P-1 is 250 cfs; P is 150 cfs; and P-1-a is 50 cfs.

Operation. The system is operated to transport water to and through the Lower Klamath Refuge that is considered excess to the Tule Lake Sumps. Pumping Plant D removes water from the Tule Lake Sump and discharges into the P-Canal Outlet Tunnel. The water is then used by individuals, the Refuge, or discharged to the Klamath Straits Drain and thence the Klamath River. On occasion, Pumping Plant D is not pumping to meet objective levels in the sump. During these periods "Special Pumping" is allowed so that water users in Lower Klamath Lake can get water.

Pursuant to a purchase order from Reclamation, the canals in this system are periodically chained to remove aquatic growth (a heavy chain is dragged along the bottom of the canal to dislodge the weeds rooted in the bottom).

During some times of the year the canal system is allowed to drain out. This depends upon water requests, D plant pumping, and refuge water needs.

14. Klamath Straits Drain (Pumping Plants E, EE, F & FF)

The Klamath Straits Drain, constructed in 1941 and operated by Reclamation, begins at the Oregon-California border and proceeds north to the Klamath River. It is a 60 ft wide x 4-6 ft deep x 8.5 mile earth channel with relift pumping stations. The water is relifted twice by pumps and is then discharged to the Klamath River. The Straits Drain is in the Lower Klamath National Wildlife Refuge which in turn receives drainage water from the Tule Lake National Wildlife Refuge. The Straits Drain was enlarged in 1976 to provide additional capacity to drain problem areas within the Refuge. Maximum flow is 600 cfs.

Operation. The Klamath Straits Drain is operated at levels that will provide adequate drainage to both private lands and refuge lands. The pumps are operated to meet the flow conditions within the drain. Water quality conditions are monitored continuously near the outlet of the channel to the Klamath River.

15. Ady Canal Headworks (Southern Pacific Railroad Crossing at Ady)

The structure, a concrete box culvert with slide gates and stoplogs, was constructed in 1912 by the Southern Pacific Railroad in cooperation with Reclamation to control the water flow into the lower Klamath Lake area through the Klamath Straits Channel. It is operated by Reclamation. At the present time these gates are left open to allow irrigation water into the lower Klamath area in a controlled manner. Water flow is controlled by the Klamath Drainage District using automatic gates located downstream from this facility. Irrigation flow is 250 cfs.

Operation. Gates at the railroad are left in the open position all the time. Flow through the structure is controlled by the district's automatic gates located downstream.

16. Minor Laterals

Numerous small laterals were constructed by Reclamation beginning in 1905. The 680 miles of earth channels (some are concrete lined) provide irrigation service to agricultural lands. Very little water is diverted directly from the main canal systems on the Project. Approximately 95% of the deliveries to farms occur from the small laterals. The laterals range in depth from one foot to over five feet and in width from two foot to over twenty feet. Maximum flow ranges from 0 to 250 cfs.

Operation. The laterals are operated by the various irrigation districts to provide field deliveries of irrigation water to farmers. Flows are dictated by the requirements of the farmers and the

capacities of the laterals. As a rule, the laterals are drained during the non-irrigation season and refilled at the beginning of the season. During the drain down of the laterals in the fall water is released to drains and directly to the river systems depending on location.

Laterals are periodically cleaned of sediment during the non-irrigation portion of the year. During the irrigation season, the laterals and canals are treated with herbicides to suppress the growth of aquatic weeds within the canal prism.

17. Minor Drains

Hundreds of small earth channel drains, a total of 728 miles in length, were constructed by Reclamation beginning in 1905. They provide drainage to agricultural lands which receive irrigation water from Project facilities. The drains range in depth from a few feet below the land surface to over ten feet in depth. In most cases water remains in the drains year round. The terminus of most drains is either in the Lost River or the Klamath River. Maximum flows are 0 to 300 cfs.

Operation. The drains are operated to provide for agricultural drainage. Maintenance activities include periodic cleaning of the drains to maintain flows. Some relift pumping plants are located on the drainage system.

18. Project Diversions

From 1997 - 2000, Reclamation inventoried water diversions throughout the Klamath Project service areas and has prepared a preliminary draft report, identifying 193 diversions owned by federal, state, irrigation districts, or private entities. Private diversions represent the largest number, 122. Of these 132 were documented in the Lost River area and 61 are on the Klamath River from Link River Dam to Keno. Diversions are both gravity fed and pumped with a wide variance in capacities and duration of operation. Most of the large diversions are gravity fed. Only three of these diversions have fish screens. The Oregon Department of Fish and Wildlife has placed screens on their Miller Island Wildlife Area diversions. Reclamation's Agency Lake Ranch diversion is scheduled to be screened in 2001 and A-channel in 2003.

Outside of the Klamath Project Service area, Reclamation estimated Klamath Lake diversions by assigning one diversion to each property. Twenty four large diversions were estimated.

19. Pumping Plants (General)

There are numerous small pumping plants on the Klamath Project that relift irrigation water and drainage flows. These plants are generally less than 10 cfs (1 cfs to 100 cfs) and are located throughout the Project. They are all electrically operated and in some cases are automatic. They range from low head slow revolution to high speed turbine pumps. Most if not all have trashracks associated with them that must be cleaned periodically but are not screened to minimize fish entrainment. Some of the pumps are operated by districts and far more are operated by individuals for their farming operations.

Operation. The pumps are operated on crop demand to remove drainage water or provide irrigation. Some of the pumps are used all year long and others only during the irrigation season.

20. Direct Farm Deliveries (Water User-operated Facilities)

Water users receive their irrigation supplies, for the most part, through turnouts or pumps constructed on canals and laterals. The farmer then applies the water to fields for the irrigation of crops. In some cases farms are supplied by drains and relift pumps. Drains collect water from previously irrigated fields and move the water to the next point of diversion.

Operation. Water use is controlled by the respective irrigation districts. Scheduling of water deliveries allows the irrigation of all lands in rotation. The farmer orders a specific amount of water in advance of need

21. Refuge Operations (Project Lease Lands)

The Lower Klamath, Tule Lake, Upper Klamath Lake, and Clear Lake National Wildlife Refuges are integral with the operations of the Klamath Project. Decisions by the US Fish and Wildlife Service are made during the year as to management of marshlands and farmlands. These decisions have an impact upon the operations of the Bureau of Reclamation.

22. Klamath Project Lease Areas

The Klamath Project is responsible for leasing over 23,000 acres of farmland to individuals residing mostly in the Klamath Basin. These leases generated 1.5 to 2.6 million dollars in annual revenue in recent years.

The Kuchel Act (PL 88-567) governs the leasing of these lands. The Act states in part:

> ***Sec. 4.*** *The Secretary shall, consistent with proper water fowl management, continue the present pattern of leasing the reserved lands of the Klamath Straits unit, the Southwest Sump, the League of Nations unit, the Henzel lease, and the Frog Pond unit, all within the executive order boundaries of the lower Klamath and Tule Lake National Wildlife Refuges Leases for these lands shall be at a price or prices designed to obtain the maximum lease revenues. These leases shall provide for the growing of grain forage, and soil building crops...(78 Stat. 851; 16 U.S.C. § 695n)*

Operation. Leases are renewed during December and any leases not renewed or coming up for re-bidding are offered in February to area farmers. All leasing arrangements are approved by the U.S. Fish and Wildlife Service prior to being offered.

23. Agency Lake Ranch

Reclamation entered into a lease of approximately 7,123 acres of land that is adjacent to Agency Lake in Klamath County. The purpose in leasing this ranch is to enhance the storage capability of Upper Klamath Lake .

Approximately 7,000 acre-feet of water is diverted over approximately 7-14 days during the time that inflow to Upper Klamath Lake is in excess of the lake's current ability to store the runoff in

the reservoir. Water delivery to the ranch occur during April from Sevenmile Canal at the terminus of Sevenmile Creek. Maximum diversion rate will be 300 cfs.

Water is pumped back into the lake when surface elevation of the lake is decreasing during May. Approximately three weeks is required. Enough water is left on the ranch to maintain soil moisture and limit the release of nutrients from the organic peat soils.

Monitoring for juvenile and adult fish populations in Sevenmile Canal is done prior to beginning water diversions. The Service is notified if juvenile and /or adult suckers are found in the vicinity of the diversion to deveop a method to ensure that entrainment of these fish does not occur. Reclamation has used a block net (one-inch square mesh) in the Sevenmile Canal to limit possible entrainment fo fish during diversions and will install a fish screen in 2001.

Any suckers that become trapped in the impoundment during dewatering are rescued. Water quality in the impoundment and water entering and leaving the ranch is monitored.

24. A-Canal

The A-Canal (Main), constructed in 1905, was the first irrigation facility completed on the Klamath Project. The canal supplies irrigation water, either directly or indirectly through return flows, to the majority of the Project. The headworks for the canal are located on Upper Klamath Lake west of the City of Klamath Falls and are operated by the Klamath Irrigation District (KID). The earth channel with lined sections is 60 feet wide x 8 feet deep x 9 miles long.. Maximum Flow are 1,150 cfs.

Operations. The canal is operated on a demand basis. Generally, the canal is charged with water in March or April. Flows average 500 cfs for this charge-up period. Orders for water are placed by irrigators with the watermaster who then schedules the flow in the canal. At the end of the irrigation season, generally during October, the canal is drained into the Lost River and the Lost River Diversion Channel.

25. The New Earth Company Algae Harvesting Facilities

<u>C Canal Algae Harvest Facility</u>

New Earth is permitted by Reclamation to operate and maintains an algae harvesting and processing facility at the head end of the C Canal. All of the water that flows down the C canal (average flow 535 cfs) will pass through 630 sq. ft. of debris reduction devices (DRDs) to remove coarse debris (3/8 inch mesh). Operation of the DRDs will be ensured by manual removal and cleaning several times a day. Water is then routed through a series of distributary pipes to the screening infrastructure. At that structure, water is passed by gravity flow over a series of fine mesh algae harvest screens that are elevated above the C Canal. The algae and any entrained larval fish are removed and the water returned to the C Canal downstream of the harvest facility. Algae concentrated on the screens is washed into collection channels adjacent to the screens and pumped in a slurry to the processing building adjacent to the canal.

In all described harvest senarios, the described harvest period will vary slightly depending on growing conditions in the lake. In general, algae harvest takes place during the summer when the algae is most concentrated, approximately June 1 to October 15. During harvest the fine mesh screens from which the algae is harvested are operated 24 hours a day. During 1995, approximately 20% of the flow from the C Canal during the harvest season was passed through

the facility screens. In 1996, additional screens were being added to allow for processing of 100% of the C Canal flow. DRDs may be operated 24 hours per day, during all algae harvest activities or between June 1 and October 15, whichever is greater. Operations of the DRDs is ensured by manual removal and cleaning several times a day. (USBR 1996)

B Canal Algae Harvest Facility

New Earth received approval from Reclamation to expand their facilities at the C Canal to harvest algae from the adjacent B Canal. A total of six pumps may deliver water from behind 450 ft. sq. of DRDs located within the walls near the head of the B Canal to a series of fine mesh algae harvest screens suspended above the B Canal. There, algae and any entrained larval stage fish will be removed. This process allows New Earth to harvest virtually all algae from water that flows through the A canal without blocking fish from passing down the B Canal and possibly into the Lost River. DRDs will be operated 24 hours a day, during all algae harvest activities or between June 1 and October 15, whichever is greater. Operation of the DRDs will be ensured by manual removal and cleaning several times a day. (USBR 1996)

26. Link River Diversion Dam and Upper Klamath Lake

Link River Dam, also known as Link River Diversion Dam, is a feature of the Klamath Project, and is located on the Link River just west of the city of Klamath Falls, Oregon. The dam was completed in 1921 and is operated by PacifiCorp under contract to Reclamation to provide hydroelectric power production, flood control, and diversion of irrigation water.

The reservoir, Upper Klamath Lake, is for the most part a natural lake that covers an area of 85,000 acres at reservoir water surface elevation 4143.3. It has an active storage capacity of 523,700 acre-feet between elevations 4143.3 and 4136 and an inactive storage capacity of 211,300 acre-feet between elevations 4136 and 4126. The dead storage volume below elevation 4126 has not been determined.

An unusual condition exists at Link River Dam in that hydraulic control of large outflows from Upper Klamath Lake is established at a reef located at the south end of the lake, approximately 0.4 miles upstream from the dam. A 100-foot-wide channel was cut through the reef to an invert elevation of 4131 feet when the dam was constructed; the remaining portion of the reef is at approximate invert elevation 4138. Because of the controlling influence of this reef, it is possible during large flood events to have reservoir water surface elevations in Upper Klamath Lake higher than the top of dam elevation of 4145.0, while water surface elevations between the dam and the reef are below the top of dam, provided that the dam gates are opened sufficiently to pass the water that flows over the reef. At maximum reservoir water surface elevation of 4143.3 feet, the maximum reef discharge is 8,500 cfs (USBR Web). Prior to construction of the Link River Dam, upper Klamath Lake levels fluctuated between 4140 and 4143 feet (USBR 2001).

Link River Dam is a reinforced concrete buttress and slab diversion structure consisting of multiple slide gate and stoplog bays with a common operating deck at elevation 4145.0. It has a structural height of 22.0 feet, a hydraulic height of 8.0 feet, and a crest length of 435.0 feet.

There is a total of 44 flow-through outlet or spillway bays (one spillway bay has a fish ladder constructed on its downstream side). At the east (left) end of the dam are seven canal-outlet bays through which water flows into the East (or Ankeny) Canal. The fish-laddered spillway bay is the next bay to the right of the Ankeny Canal outlets. Continuing west from the fish-laddered bay

toward the right side of the dam, there are 24 stoplogged spillway bays. Immediately to the west of the spillway section are six river-outlet bays. To the right of the river-outlet section at the west (right) end of the dam are six canal outlet bays through which water discharges into the West (or Keno) Canal.

The Ankeny canal-outlet section at the left end of the dam is composed of seven bays, each with a 5.0-foot wide by 7.0-foot high slide gate; each of the slide gates has its own electric-motor driven hoist. This gate section is the headworks structure for the Ankeny Canal which supplies water to a 12-foot diameter wood stave pipe that leads to the East Powerplant. The sill elevation of each gate bay is 4130 feet. The capacity of the pipe limits the discharge from the gate structure to 1,000 cfs.

Twenty-four of the 25 spillway bays are equipped with 8-foot wide timber or concrete stoplogs. The 10 right-most spillway bays are equipped with steel-framed concrete panel stoplogs; the remaining spillway stoplogs are made of wood. The fish-laddered bay is not stoplogged. Stoplogs are removed and installed with an overhead monorail electric hoist and trolley. The crest elevation of each of the spillway bays is 4135 feet. The combined design discharge capacity of the spillway section is 13,000 cfs.

The river-outlet gate section consists of six bays, each with a 5.0-foot-wide by 7.0-foot high slide gate. The sill elevation of each gate is 4130 feet. The four gates on the right side of the river-outlet section are identical to the gates within the adjacent west canal outlet section, and are operated with the same gantry-mounted chain-and-sprocket assembly. The two left-most river-outlet gates have their own individual electric motor drive hoists. A stilling basin was constructed for the river-outlet section in 1952. The design discharge capacity of the river-outlet section is 3,000 cfs.

The Keno canal-outlet section at the right end of the dam forms the headworks for the Keno Canal. This canal-outlet section consists of six gate bays, each bay with a 5.0-foot wide by 7.0-foot high slide gate. The sill elevation of each gate bay is 4129 feet. The slide gates are operated by screw-lift hoists that are driven by an electric-motor driven chain-and-sprocket assembly, that is mounted on a gantry. The Keno Canal delivers water to the West Powerplant; the discharge from the west canal-outlet structure is limited to 2~~9~~50 cfs by the capacity of the Keno Canal. Only two of the Keno Canal slide gates (the second and fourth gates from the right end of the dam) are routinely used to make releases into the canal (USBR Web).

Link River Dam provides regulation of Upper Klamath Lake and is operated pursuant to a Reclamation contract with Pacific Power (formerly Copco).

8.D. PacifiCorp Project Facilities

The physical description of the Link River Dam facility is discussed above. Reclamation has management control of Upper Klamath Lake elevations and Iron Gate dam releases. PacifiCorp operates Link River Dam and Iron Gate Dam releases under the direction of Reclamation. Reclamation's control of operational conditions, coupled with relatively small active storage in the Klamath Hydroelectric Project reservoirs means that PacifiCorp's operations have little or no control over the river's flow regime, except on a short-term (hourly, daily) basis and at certain locations (PacifiCorp 2000).

Link River Dam and the associated Eastside (3.2 megawatt [MW]) and Westside (0.6 MW) powerhouses are the most upstream facilities, located near RM 254 within the city limits of Klamath Falls, Oregon. Reclamation owns the Link River dam and PacifiCorp operates it under

Reclamation's directive. The dam was built to supply water to both the Project and PacifiCorp's Klamath Hydroelectric Project. The Eastside and Westside powerhouses and associated waterways are part of a FERC project. Keno Dam, a re-regulating facility with no generation capability, is the next facility, 20 miles downstream at RM 233. Keno reservoir buffers inflow and outflow of USBR's Irrigation Project. The next facility is J.C. Boyle (80 MW). The dam is at RM 224.7 and the powerhouse is several miles downstream at RM 220.4. As the river continues into California, it enters Copco reservoir, which supplies Copco No. 1 (20 MW) and No. 2 (27 MW) hydroelectric facilities, at RM 198.6 and RM 196.8, respectively. The Iron Gate facility (18 MW) is farthest downstream at RM 190. Fall Creek, a tributary, flows through a small powerhouse (2.2 MW) and then into the upper end of Iron Gate reservoir (PacifiCorp 2000).

8.D.1. PacifiCorps' Eastside and Westside Facilities

Link River Dam, located at RM 254 in Klamath Falls, Oregon, is the Project-related facility furthest upstream and the point of diversion for the Eastside and Westside powerhouses. Construction of Link River Dam was completed in 1921. The dam is a reinforced concrete slab about 16 feet high. The spillway section consists of six spill gates and numerous removable stop log spill gates. The Eastside facilities consist of 1,729 feet of wood-stave flowline, 1,362 feet of steel flowline, a surge tank, and a powerhouse on the east bank of Link River. The Westside facilities consist of a 5,575-foot-long earthen canal, 140 feet of steel penstock, and a powerhouse on the west bank of the Klamath River. Maximum diversion capacity for the Eastside powerhouse is 1,200 cfs; for Westside it is 250 cfs. The Eastside powerhouse consists of a single Vertical Francis 3.2-MW unit. The Westside powerhouse consists of a Horizontal Pit-type Francis 0.6-MW unit.

There are no fish screens at the Eastside and Westside canal intakes from the Link River Dam. A pool and weir type fish ladder was constructed at the dam in 1926 and modified with a vertical slot entrance pool in 1988. Reclamation owns the ladder and PacifiCorp operates it. The ladder consists of 11 pools, is approximately 105 feet long, and provides for approximately 13 feet in elevation gain. Flow through the ladder is dependent upon Upper Klamath Lake water surface elevation and is adjusted manually by PacifiCorp operators. The affected reach between the Link River Dam and the Eastside powerhouse tailrace is approximately 2,600 feet long.

The Link River Dam provides regulation of Upper Klamath Lake, diverts water from the lake to the Eastside and Westside powerhouses, and releases a minimum flow in the Link River reach between the dam and the Eastside powerhouse. Upper Klamath Lake is not part of PacifiCorp's Klamath Hydroelectric Project. PacifiCorp operates the Link River Dam and maintains lake levels and releases flow at Reclamation's direction by following an operating range dictated by spring runoff conditions. Reclamation directs operations according to a contract with PacifiCorp. Operations must balance the requirements for (1) ESA species found in Upper Klamath Lake and downstream, (2) irrigation, and (3) power, while maintaining sufficient carryover storage. Should operations threaten irrigation supplies, Reclamation reserves the right to take over facility operation.

The total storage capacity of Upper Klamath Lake is 523,700 acre-feet, which represents most of the storage capacity in the entire basin (PacifiCorp 2000). Prior to construction of the Link River Dam, Upper Klamath Lake fluctuated 3 feet, from 4140 to 4143 ft (USBR 2001). Following dam construction, normal operating conditions at Link River Dam historically provided for a 6.3-foot lake fluctuation, although current lake elevations are dictated by the 1996 BO. Such operations result in an annual fluctuation of 4.3 feet. Over the last several years, lake elevations have been increased to full pool elevation (4,143.3 ft msl) just before onset of the irrigation

season in May, followed by a gradual drawdown until the end of the season in mid-October.

Diversions to the Eastside powerhouse are somewhat variable, as flow through the powerhouse is operated to regulate Upper Klamath Lake and Keno reservoir water surface elevations and to ensure instream flows downstream of Iron Gate Dam. Diversions to the Westside powerhouse are either 0 or 230 cfs. Flows through the facility cannot be varied as at the Eastside powerhouse, thus the Westside powerhouse is either at 230 cfs flow and generating or at 0 cfs and shut down. Changes in flows into Keno reservoir can include altering flows through the Eastside powerhouse or adjusting spill at the Link River dam. The minimum affected reach instream flow is 90 cfs, based on an agreement between Oregon Department of Fish and Wildlife (ODFW) and PacifiCorp. An allowable rate of change in flow released at the dam (hereafter referred to as the ramp rate) became a standard operating procedure in the 1980s, based on discussions with ODFW. The ramp rate is now part of the 1996 BO issued by the Service that PacifiCorp follows in operating the dam.

The ramp rate for the reach between Link River Dam and the Eastside powerhouse requires that flows change by no more than (1) 100 cfs in 30 minutes when release flows are between 500 and 1,500 cfs, (2) 50 cfs in 30 minutes when release flows are between 300 and 500 cfs, and (3) 20 cfs in 5 minutes when release flows are between 0 and 300 cfs. A fish salvage must be conducted in side channels if flows drop below 350 cfs. As per PacifiCorp's operations and maintenance plan written for the 1996 BO, the minimum flow downstream of the Eastside powerhouse is 450 cfs. At flows less than this, a fish salvage must be conducted.

Turbine maintenance typically is on an annual basis and occurs at both powerhouses during the spring. Outages usually occur for approximately 5 days. Dewatering of the waterways is not always necessary. Instream flow in the bypass reach and downstream of the Eastside powerhouse is maintained by spill at Link River Dam.

8.D.2. Keno Facilities

Keno Dam is a re-regulating facility located at about RM 233, approximately 21 miles downstream of Link River Dam. There is no power generating capability at this facility. Construction of Keno Dam was completed in 1967. The concrete dam has a height of 25 feet and a spillway width of 40 feet through each of the six spill gates. The impoundment upstream of the dam has a surface area of 2,475 acres and a total storage capacity of 18,500 acre-feet. There is a 24-pool weir and orifice type fish ladder at the dam. This fish ladder gains 19 feet in elevation in approximately 350 feet. The Klamath River reach from Keno Dam downstream to the J.C. Boyle reservoir is about 5 miles long.

Keno Dam operates as an agricultural diversion dam to control elevations of Keno reservoir for the Project. PacifiCorp built the facility intending to produce hydroelectric power, but the facilities were never developed. The constant reservoir level allows irrigators to withdraw water during the growing season and the dam regulates river level fluctuation from variable agricultural return flows. As per a FERC license, PacifiCorp has an agreement with ODFW to release a minimum stream flow of 200 cfs at the dam. Flows through Keno Dam generally mimic instream flows downstream from Iron Gate dam and approach the minimum flow only during critically dry water years. Reservoir levels rarely fluctuate more than 6 inches seasonally, although the reservoir may be drawn down about 2 feet annually for 1-2 days to provide an opportunity for irrigators to conduct maintenance on their pumps and canals. There is no ramp rate requirement for flow released from the dam. Controlling releases in this way would be very

difficult, since agricultural return flows are not regulated. Furthermore, controlling flows according to a ramp rate would cause reservoir levels to fluctuate, thereby compromising the irrigators' ability to obtain water via the pumps.

As there is no generating facility at Keno Dam, turbine maintenance is not an issue. However, spill gate testing is conducted annually and at 5-year intervals. Each spill gate is partially opened during annual maintenance testing and fully opened during 5-year testing to ensure that the operator motors are functioning correctly. This testing is usually conducted in the spring during periods of high river flow.

8.D.3. J.C. Boyle Facilities

The J.C. Boyle development consists of a reservoir, dam, diversion canal, and powerhouse on the Klamath River between about RM 228 and 220. Construction was completed in 1958. J.C. Boyle facilities consist of an earth-filled dam 68 feet tall impounding a narrow reservoir of 420 surface acres (J.C. Boyle reservoir). The impoundment formed upstream of the dam contains about 3,495 acre-feet of total storage capacity and 1,724 acre-feet of active storage capacity, according to facility drawings.

The dam has three spill gates and can divert up to roughly 3,000 cfs, which is the hydraulic capacity of the powerhouse. The intake from the dam to the power canal is screened with four vertical traveling screens (0.25-inch mesh) with high-pressure spray cleaners. A weir with cleaning orifice fish ladder approximately 569 feet long with 57 pools is located at the dam for fish passage. The change in elevation between pool 1 and pool 57 is about 67 feet.
The concrete-walled canal extends just over 2 miles along a cliff face before entering a tunnel and steel penstocks. The powerhouse is located about 4.3 RM downstream of the dam. Each penstock serves a separate 40-MW unit. The next downstream facility is Copco No. 1 reservoir, approximately 17 miles away.

The J.C. Boyle development generally operates as a load-factoring facility when flow is not adequate to allow continuous and efficient operations. This type of operation results in flows from the powerhouses that vary according to power demand. Normal operation at the J.C. Boyle facility is to generate electricity at efficient loadings with available water. Generation occurs when there is sufficient water available for efficient use of one or both turbines. As a result, flows downstream from the powerhouse may fluctuate on a daily basis, based on the amount of water available to the plant. High river flows in excess of powerhouse hydraulic capacity or efficient loadings of the units can allow continuous operation of the powerhouse. During cold weather conditions, the plant generates power around the clock, not necessarily at peak efficiencies, to prevent freeze damage to the canal or equipment.

The load-factoring operation allows commercial and recreational rafting opportunities from the powerhouse to Copco reservoir from May to mid-October. During that period, timing of flow release may be in part determined by rafting use in the downstream reach.

The minimum flow requirement, as established in the FERC license (FPC 1956), from the dam into the roughly 4-mile-long affected reach is 100 cfs (the reach of the Klamath River channel between the dam and the powerhouse). However, large springs within the affected reach supply an estimated additional 350 cfs of accretion flow, such that actual minimum flows in the reach are approximately 450 cfs or greater. River fluctuation downstream of the dam and the powerhouse are limited to a 9-inch-per-hour ramp rate, as measured at the U.S. Geological Survey (USGS) gage 0.25 mile downstream of the J.C. Boyle powerhouse, as established in the

FERC license (FPC 1956). Operating conditions can result in a fluctuation of about 3.5 feet between minimum and full pool elevations in the J.C. Boyle reservoir, but the average daily fluctuation is about 2 feet. There are no specific requirements established for reservoir fluctuations.

Facility maintenance is usually scheduled on an annual basis in the fall, following the whitewater recreation season. Unit outages usually last 2 weeks or less and are offset to allow generation at the other unit to continue. Canal maintenance typically is a 1-day event that results in dewatering the canal, removing rocks that have fallen into the canal, and inspecting the canal wall. To prevent the loss of fish that might be in the canal, a fish salvage occurs as the canal is dewatered. As at Keno Dam, partial spill gate testing is conducted annually and a full spill gate test is conducted every 5 years.

8.D.4. Copco No. 1 Facilities

The Copco No. 1 development consists of a reservoir, dam, and powerhouse located on the Klamath River between about RM 204 and RM 199 near the Oregon-California border (Figures 2-1 and 2-2). Generation at unit 1 began in 1918. Copco No. 1 Dam is a concrete arch dam 126 feet high, with 13 spill gates across the top. The impoundment formed upstream of the dam is approximately 1,000 surface acres containing about 45,500 acre-feet of total storage capacity and 6,235 acre-feet of active storage capacity. The Copco No. 1 powerhouse is located at Copco dam and has two Double Runner Horizontal Francis turbines, each 10 MW. Combined hydraulic capacity of the turbines is roughly 3,200 cfs. Water diverted through the Copco No. 1 powerhouse is directed to the Copco No. 2 powerhouse intake (described below) through the approximately 1 mile-long reservoir.

Copco No. 1 Dam operates for power generation, flood control, and control of water surface elevations of Copco and Iron Gate reservoirs. Like the J.C. Boyle development, Copco No. 1 generally operates as a load-factoring facility, usually from spring to high flows in early winter. Typical operation is to generate during the day, when energy demands are highest, and store water during the non-peak times (weeknights and weekends). When river flows are near or in excess of turbine hydraulic capacity, the powerhouse generates continuously and excess water is spilled through the spill gates. There are no minimum instream flow or ramp rate requirements for the short downstream reach between Copco No.1 and Copco No. 2 developments. Copco reservoir can fluctuate 5.0 feet between normal minimum and full pool elevations, but the average daily fluctuation is about 0.5 foot. There are no specific requirements established for reservoir fluctuations.

Maintenance at Copco No.1 is an annual event and typically occurs in the spring. Maintenance on each turbine unit requires a shutdown of approximately 2 weeks. Depending on time of year and river flow, water might be spilled over the dam. Annual and 5-year spill gate testing is also conducted.

8.D.5. Copco No. 2 Facilities

The Copco No. 2 development consists of a diversion dam, small impoundment, and powerhouse located just downstream of Copco No.1 dam between about RM 198.3 and RM 196.8 (Figures 2-1 and 2-2). The reservoir created by the dam has minimal storage capacity (73 acre-feet). As a result, Copco No.2 is entirely dependent upon Copco No.1 for water to generate with and functions as a slave to the Copco No.1 powerhouse.

Completed in 1925, the Copco No. 2 Dam is small compared to Copco No. 1 Dam, being only 33 feet high. The conduit to the powerhouse consists of portions of wood-stave, rock tunnel, and steel penstock. Two Vertical Francis (13.5 MW each) units with a combined hydraulic capacity of 3,200 cfs reside in the powerhouse.

Copco No. 2 operation follows that of Copco No. 1. Water spills over the spillway crest when flows from Copco No. 1 exceed the hydraulic capacity and limited storage capacity of this facility. There are no minimum instream flow or ramp rate requirements for the short (about 1.5 miles) downstream reach between Copco No. 2 dam and Iron Gate reservoir, but PacifiCorp releases a minimum flow of 5-10 cfs as standard operating practice. Water surface elevations of the reservoir rarely fluctuate more than several inches. No specific requirements have been established for reservoir fluctuations.

Maintenance at Copco No. 2 is an annual event, typically occurring in the spring. Maintenance on each turbine unit requires a shutdown of approximately 2 weeks. Depending on time of year and river flow, water might be spilled over the Copco No. 2 dam. Annual and 5-year spill gate testing is also conducted.

8.D.6. Iron Gate Facilities

The Iron Gate development consists of a reservoir, dam, and powerhouse located on the Klamath River between about RM 196.8 and RM 190 about 20 miles northeast of Yreka, California. Iron Gate is the part of the Klamath Hydroelectric Project farthest downstream. The rock-fill Iron Gate Dam was completed in 1962 and is 173 feet high. The impoundment formed upstream of the dam is approximately 944 surface acres and contains about 58,794 acre-feet of total storage capacity and 3,790 acre-feet of active storage capacity. An ungated spillway 730 feet long leads to a large canal, allowing the transport of high flows past the structure. The powerhouse is located at the base of the dam and consists of a single Vertical Francis unit (18 MW) with a hydraulic capacity of 1,735-cfs.

The Iron Gate facility is operated for base load generation and for providing stable flows in the Klamath River downstream of the dam. It also provides the required minimum flows downstream of the facility. During periods of high flow, when storage is not possible, water in excess of generating capacity passes through the spillway.

FERC stipulated minimum instream flow requirements to protect downstream aquatic resources as a condition of PacifiCorp's current Project license. FERC minimum flows are 1,300 cfs from September through April, 1,000 cfs in May and August, and 710 cfs in June and July. Since 1996, however, Reclamation's annual Project Operation Plans have dictated instream flow releases. During that time, instream flow releases from Iron Gate Dam, as required by the annual Project operation plans have generally exceeded the required FERC instream flows.

Downstream river fluctuation caused by releases at Iron Gate Dam are limited to the lesser of a 3-inch-per-hour or 250-cfs-per-hour ramp rate as established in the FERC license (FPC 1956). Iron Gate reservoir can fluctuate a maximum of about 8 feet between normal minimum and full pool elevations. Average daily fluctuation is roughly 0.5 foot. There are no specific requirements established for reservoir fluctuations.

With no spill gates at the dam and just a single unit, maintenance at the Iron Gate powerhouse involves a single annual outage typically lasting 2 weeks. Due to the need for river levels less

that 2,000 cfs (to allow the crew safe access to the turbine), maintenance typically occurs in late spring. To maintain downstream Klamath River flows, water is spilled over the dam.

8.D.7. Fall Creek Facilities

The Fall Creek development is located on Fall Creek, a tributary of the Klamath River, approximately 0.4 miles south of the Oregon-California border. The Fall Creek development consists of two small diversion dams, an earthen ditch, a penstock, and a powerhouse. The upstream-most diversion is located on Spring Creek; when in use it diverts water over to Fall Creek. The diversion on Fall Creek then diverts water into the waterway that supplies the powerhouse. Since both streams are predominantly spring fed, there is no storage reservoir and the powerhouse operates as a run-of-the-river facility. A 69-kV transmission line of approximately 1.7 miles extends from the powerhouse to the Copco No. 1 development.
Built in 1903, the Fall Creek hydroelectric facility is one of PacifiCorp's oldest. The dam on Fall Creek is a log crib, earth filled diversion dam. Waterway length from dam to penstock intake is approximately 4,560 feet. The penstock drops over the hillside, providing a 730-foot head to the three Pelton turbines in the powerhouse. Generation capacity is 0.5 MW for Unit No. 1, 0.45 MW for Unit No. 2, and 1.25 MW for Unit No. 3. Hydraulic capacity of the three turbines totals 50 cfs.

The Fall Creek facility is operated for base load generation. It also provides the required minimum flow of 15 cfs downstream of the facility. During periods of higher flow, water in excess of diversion capacity (50 cfs) passes over the diversion dam. FERC minimum flow requirements are 0.5 cfs at all times from the Fall Creek diversion dam into Fall Creek, and a 15-cfs continuous flow in Fall Creek (or a quantity equal to the natural flow of the stream, whichever is less) at the outlet of the powerhouse tailrace.

Maintenance at the Fall Creek facility is scheduled annually and usually occurs in the summer. With three generating units, one unit can be shut down for maintenance while the others continue to operate. A typical shutdown lasts 1 to 3 days per unit. If there is a need to completely shut off water to the powerhouse, downstream flows can be met by removing diversion boards at the dam or by spilling canal water at the penstock intake back into the bypass reach.

8.D.8. Transmission Lines

The eight transmission line segments associated with the Project are dedicated solely to Project facilities. From the Eastside facility, line 11-8 (69 kV) crosses the bypass reach and connects the powerhouse to a tap point on line 11. The Westside plant has no associated transmission lines, since all adjacent lines would still exist, apart from the facility.

One short transmission line is associated with the J.C. Boyle powerhouse. Line 98 (69 kV), also referred to as line 18-4 on the FERC drawing, connects the powerhouse to a tap point on line 18. This line is currently idle.

Two line segments are associated with the Fall Creek powerhouse. Line 3 (69 kV) connects the Fall Creek powerhouse to Copco No. 1 switch yard, approximately 1 mile to the east. Another very short segment of line 3 connects the powerhouse to a tap point on line 18, which runs nearly overhead.

Three lines are associated with Copco No. 1 powerhouse. Line 15 (69 kV) connects Copco No. 1 switch yard to Copco No. 2, approximately 1 mile to the west. Lines 26-1 (69 kV) and 26-2 (69 kV) connect Copco No. 1 switch yard to Copco No. 1 powerhouse. No transmission lines are associated with Copco No. 2 powerhouse.

One line is associated with Iron Gate powerhouse. Line 62 (69 kV) runs along the north side of the reservoir, from the powerhouse to Copco No. 2.

D. Contractual Relationships

Repayment Contracts

The Project water users obtain their irrigation water supply from Project facilities pursuant to various contracts with Reclamation. Reclamation obtained water water rights for the Project in accordance with California and Oregon State law, pursuant to the Reclamation Act of 1902. The priority date for Project water rights is generally 1905, and some rights may date from 1878.

Reclamation entered into numerous contracts pursuant to Article 9(d) of the Reclamation Act of 1904 with various irrigation districts to provide for the repayment of Project costs and the granting of water rights. The contracts specify an acreage to be covered by the water right granted and in most cases do not specify an amount of water relying on beneficial use for the amount of water used. The contracts are all written in perpetuity.

In all, over 250 contracts for water service are administered either directly or through irrigation districts on the Klamath Project. Contracts also cover the operation of the system that was transferred to the water users for operational responsibility. Irrigation Districts that fall into this category are Klamath Irrigation District, Tule Lake Irrigation District, and the Langell Valley Irrigation District.

In addition to the above, the Bureau of Reclamation entered into numerous contracts that were written pursuant to the Warren Act of 1911. These contracts provided for a water supply at a certain point, with the responsibility of the contractor to construct all the necessary conveyance facilities (i.e. pumps, laterals, and turnouts) and be responsible for operation and maintenance.

Some of the districts and their respective contracts that own all or a portion of their systems are (Only the most recent contract is listed):

District Name	Contract Date	Acreage
Van Brimmer Ditch Company	November 6, 1909	3,315
Klamath Basin Improvement District	April 25, 1932	10,403
Enterprise Irrigation District	March 18, 1935	2,981
Malin Irrigation District	May 5, 1936	3,507
Pine Grove Irrigation District	June 19, 1936	927
Sunnyside Irrigation District	June 25, 1936	595
Westside Improvement District	October 20, 1936	1,190
Shasta View Irrigation District	August 20, 1938	4,141
Klamath Drainage District	April 28, 1943	19,229
Emmitt District Improvement Company	December 1, 1947	424
Midland District Improvement Company	February 2, 1952	581
Poe Valley Improvement District	July 20, 1953	2,636
Ady District Improvement Company	August 5, 1954	435
Plevna District Improvement Company	February 7, 1958	523

Horsefly Irrigation District	August 24, 1976	9,843
Upper Klamath Lake Contractors	Various contract dates	7,918
Individual Contracts	Various contract dates	9,960

Nearly all contracts written during the past 85 years on the Klamath Project obligate the United States to the delivery of irrigation water. Clauses in most contracts include language similar to the following example:

> *"The United States shall deliver in the Klamath River at the outlet of Upper Klamath Lake..in all a total of 522.7 irrigable acres, a sufficient quantity of water as may be beneficially used upon said lands...the quantity of water sufficient for the irrigation of said 522.7 acres shall be as determined by the Secretary of the Interior"*

The contracts additionally provide that the United States shall be held harmless in the event of a shortage.

Temporary Water Contracts

Each year Reclamation makes a determination if surplus water is available for sale to irrigators (See forecasting). In many cases irrigators have been receiving surplus irrigation water from Reclamation for over 50 years. For numerous reasons these irrigators were never given permanent water rights status by virtue of a long term contract with the United States. Concurrently, the districts also make a determination whether or not to sell surplus water. The irrigable acreages covered by surplus water contracts in 1990 was 3,797.0.

The acreage represented by these temporary contracts represent less than 2% of the total acreage irrigated on the Project. Water is delivered to these lands through the existing irrigation systems. In many cases the water is delivered and controlled by the irrigation districts.

National Wildlife Refuges

Four national wildlife refuges lie adjacent to or within Klamath Project boundaries: Lower Klamath; Tule Lake; Clear Lake; and Upper Klamath. These refuges were established by Executive Orders dating as early as 1908. The refuges are managed by the Service under the Migratory Bird Treaty Act, the Refuge Administration Act, the National Refuge System Improvement Act, and other laws pertaining to the suitable habitat and resources for migratory birds of the Pacific Flyway. Portions of the refuges are also used for agricultural purposes. The refuges either receive water from or are associated with Project facilities. Reclamation has an obligation to ensure that the refuges receive adequate water to fulfill their federal reserved water rights (i.e., the amount of water necessary to fulfill the primary purposes of the refuges) when in priority and when water is available. In addition, Reclamation can continue to provide available Project water for beneficial reuse by the refuges to the extent of past and current usage and consistent with Project purposes (DOI, 1995). The refuges have federally reserved water rights for the water necessary to satisfy the refuges' primary purposes. In addition, the Lower Klamath and Tule Lake refuges have water rights based on a portion of the Klamath Project water right.

COPCO Power Contract

In 1917, the United States entered into a contract with California Oregon Power Company (COPCO) under which the power company was given the right to construct the Link River Dam at the outlet of Upper Klamath Lake, and the right to use certain amounts of water after the

requirements of the Klamath Project were satisfied. The contract was to cease, and title of the dam was to vest in the United States, 50 years from the date of execution. The contract was renewed early as a result of FERC Project 2082 concerning the construction and operation of downstream Klamath dams operated by Pacific Power (formerly COPCO).

The present contract, which will expire in 2006, allows the power company to operate the dam within certain guidelines (see above) unless it is determined by Reclamation that irrigation supplies are threatened. In 1997, the contract was modified and the modification must be renewed annually.

E. Water Rights Information

Acquired Water Rights

In addition to initiating the appropriative rights procedure in the State of Oregon, the United States acquired some early pre-project rights to use of water by purchase from landowners with prior rights entitlement. The fact that a considerable number of these rights were purchased by the United States indicates that early private development of the basin was well under way at the advent of Reclamation. It was necessary to purchase these rights from the entities involved so that Reclamation had full control of all of the rights to the use of water in the basin. The federal project would not be possible without the elimination of conflicting uses.

Appropriation by the United States

The basic water rights required for the operation of the Klamath Project are derived from certain legislation of the State of Oregon enacted in 1905 (Chap. 228, Ore. Gen. Laws, 1905); later Sec. 116.438 (Ore. Comp. Laws Annotated).

Similar legislation was enacted by the Legislature of California on February 3, 1905, relative to the Klamath Project areas in California.

On May 19, 1905, a "Notice of Intention to Utilize All Waters of the Klamath Basin" was filed by the Reclamation Service, Predecessor to the Bureau of Reclamation, in the office of the State Engineer of Oregon. It is recorded in "Water Filings" at Page 1. This notice was also published in the *Klamath Falls Express* of Klamath Falls, Oregon on June 15, 22, 29, and July 6, 1905.

The Reclamation Service of the United States filed detailed plans and specifications covering the construction of the Klamath Irrigation Project with the State Engineer, of Oregon, on May 6, 1908, and on May 8, 1909, filed with the State Engineer proof of authorization of the construction of the works therein set forth.

Prior to December 19, 1914, appropriative water rights could be acquired in California by posting and recording a notice stating the nature and quantity of the proposed appropriation and by thereafter exercising due diligence in putting the water to beneficial use. The required postings were made on behalf of the United States.

Adjudication Proceedings

A formal adjudication of a river system sets down in a competent court the relative rights to the use of water within the area that is being adjudicated. Testimony is received from all persons

claiming a right and the State makes determinations based on the testimony of the relative priority dates. The Klamath River Basin adjudication is in such a process.

In 1918 the State of Oregon began the adjudication of the Lost River system. Certificates were issued to individuals that had rights that pre-dated the Klamath Projects filings. Since Reclamation was not a party to the adjudication, certificates were not issued to Reclamation or its contractors. The State did, however, set aside 60,000 acres for Reclamation to later claim certificates on. This was a far greater amount of land than could possibly be served from the Lost River. A considerable amount of mapping of the irrigated lands was completed by the State under contract to Reclamation during the late 1980's. The intent was to finally receive certificates on the lands, however, due to several problems the certificates have not been issued.

A number of irrigators above Gerber Dam claimed to have not been notified of the 1918 adjudication. As a result the State reopened the process and completed it in 1989. This portion of the adjudication set forth the relative priorities of water use above Gerber Dam.

The Klamath River Basin Adjudication covers all Project lands served by the Klamath River. Other federal entities involved include the National Park Service, U.S. Department of Agriculture, Bureau of Land Management, the U.S. Fish and Wildlife Service, and Bureau of Indian Affairs on behalf of the Klamath Tribes. In 1975, the State of Oregon, through its Water Resources Department (OWRD), initiated the Klamath River Basin adjudication to determine all claims to surface water in the Basin. By 1986, the State of Oregon had completed a considerable amount of work in mapping the places of use within the Project.

In 1990, the OWRD reissued notices of intent to adjudicate the Klamath River Basin, and during 1991, required all persons claiming a right to the use of water from the River to file. The United States did not file, claiming that the adjudication violated the McCarran Amendment which requires that any adjudication involving the United States must be complete and include ground water. In subsequent legal proceedings, the United States lost, and as a result, all claims were to be filed with the State in April 1997 for both use and storage. Open inspection of claims was extended through March 2000. In May 2000, several thousand contests were filed on individual claimants and the State's Preliminary Evaluations of Claims.

Concurrent with the Klamath adjudication, the State of Oregon has begun an Alternative Dispute Resolution (ADR) process in an attempt to resolve as many water rights issues in the adjudication as possible to avoid litigation by various claimants. The U.S. has participated in the ADR process from its beginning, along with the Klamath Tribes, various individuals, and the Klamath Project water users. Meetings are held monthly. The ADR process may help solve disputes; however, difficult issues remain to be resolved.

The State of Oregon has proposed a broad settlement framework that is being considered by the Administrative Subcommittee of the ADR Group. In addition, the Klamath Tribes and project irrigators have negotiated a framework settlement agreement which is under review by various parties to the ADR. The Klamath Tribes have also presented a settlement proposal on the tributary area above Upper Klamath Lake. Several technical teams have been formed to deal with specific ADR issues. Reclamation actively participates on the Hydrology Technical Committee (USBR 2000a).

F. Water Supply Forecasting

Each year the Klamath Project forecasts available water supplies beginning in January. Information such as watershed conditions, carryover storage, Soil Conservation Service forecasts, projected water use for both irrigation and wildlife use, and other available data for varied sources are used by Klamath Project personnel to forecast the condition of Project systems during the ensuing year. The forecast and water supply declaration have been presented in annual operations plans since 1995.

This information is presented to the water user community as soon as practicable, usually in early May. Along with the information, the Project provides a **water supply declaration** that delineates how much water is available to meet the demands that may be placed upon it.

Should the forecast indicate that a short water supply may prevail, meetings with all affected resource agencies are held to attempt to moderate the shortages and provide a fair and equitable allocation procedure for the available supply. Full consideration is given to irrigation uses, wildlife and fishery needs, recreational uses, power needs and domestic needs. However, in cases of extreme shortage, the priorities listed in Article III of the Klamath River Basin Compact dictate the allocation. The Bureau has developed a *Drought Plan*, dated February 12, 1992, for the Project that will be followed in the event of a severe shortage. This Plan is reproduced below.

G. Tribal Trust Responsibilities

In its BA, Reclamation did not assess whether the proposed operation of the Klamath Project is consistent with its trust responsibility to the Klamath Tribes, including what lake levels comprise the water necessary for the tribal trust resources in Upper Klamath Lake. This BO does not make that assessment either, as it only concerns whether the contemplated action by Reclamation will jeopardize the listed sucker species. This trust responsibility issue will be addressed in Reclamation's annual operations plan and during the long-term planning process for the Klamath Project.

H. Drought Plan

A copy of the entire text of the Klamath Project Drought Plan is included and begins on the following page.

February 12, 1992

DROUGHT PLAN

Upper Klamath Lake Watershed

Priority and Execution Plan for Administration
of Water Rights and Water Delivery on the
Klamath Project in the Event of a Drought

General

It should be emphasized that before any actions are taken to limit the amount of water available to Project water users, efforts will be made to minimize, or possibly avert, the shortages that are forecasted. Water users will be represented in these efforts to attempt to work out a plan that will be fair and equitable to those involved.

It should also be noted that return flows generated by Project water users are an important factor in determining the total amount of water use figures. These return flows are reused many times in the agricultural use cycle and may ultimately affect several downstream users.

An emphasis would be placed on conserving water, growing crops that use less water, farming practices that will save water, possible fallowing of land that is less productive, and most important, cooperation among the water users. Only after avenues of conservation and cooperation are explored would the water be allocated on a priority basis within the Project.

One of the key themes in any prioritization of water rights on the Project is that the Bureau claims a 1905 right for all Project lands regardless of the type of contract that the water users may have. However, within the Project the Bureau can prioritize use by date of contract and type of contract. All other diverters of water not in the Project would be considered junior to Project needs if their priority date was after 1905.

There are two basic types of contracts on the Project, a 9(d) Repayment contract and a Warren Act type contract. The 9(d) type contract was used for Main and Tulelake Divisions of the Project. These Divisions were, for the most part, homesteaded by Reclamation. The Warren Act was used to grant a secondary right of use to users above the gravity system and/or not in the above mentioned Divisions of the Project.

First Priority of Use Within the Project (Class A)

The Van Brimmer Irrigation District's contract with the United States recognizes that district's right to the use of 50 ft^3/s. The United States eliminated the district's supply of water by reclaiming Lower Klamath Lake, and was then obligated to provide another source of supply. The result of that obligation is that the Van Brimmer Irrigation District has a priority that predates 1905.

The Klamath Irrigation District, also known as the Main Division, was the first land developed for irrigation and, as such, would have the first right to the use of irrigation water after Van Brimmer. The district was the successor to the Klamath Water Users Association who contracted with the United States on November 6, 1905. The first contract between the United

States and the district was dated July 6, 1918 and was written pursuant to the 1902 Federal Reclamation Act.

Tulelake Irrigation District's contract is dated September 9, 1956, and is also a 9(d) type contract. The contract specifically states that the district has the same contractual right and priority date as ther contracts written pursuant to the 1902 Act on the Project.

Federally owned areas leased by the United States are considered to have the same priority date as other Class A users. During extreme drought circumstances Reclamation may voluntarily limit deliveries to federal lease lands, thus preserving a supply to the other Class A water users.

There are several individual contracts within Klamath Irrigation District that were written pursuant to the 1902 Act in the 1970's. These are for minor acreages, somewhere in the neighborhood of 400 acres.

Second Priority of Use Within the Project (Class B)

All of the following contracts were written pursuant to the Warren Act of February 21, 1911. These contracts include a clause which states that the water right is subject to the main division land's first right. The Warren Act was cited in the contracts so that a secondary right could be issued to the contractor. The Warren Act contains a clause in Article 1 which states in part "..., preserving a first right to lands and entrymen under the project.". In addition, most of the contracts contain the very same wording. Given that understanding, the following order of precedence by contract date will be followed:

Enterprise Irrigation District. Receives water out of the A-Canal through the Klamath Irrigation District system. The date of the contract is October 5, 1920.

Klamath Drainage District. Receives water out of the Klamath River below the Link River Dam. The date of the contract is August 24, 1921.

Malin Irrigation District. Receives water out of the D-Canal through the Klamath Irrigation District system. The date of the contract is September 9, 1922

Shasta View Irrigation District. Receives water out of the D-Canal through the Klamath Irrigation District system. The date of the contract is October 6, 1922.

Sunnyside Irrigation District. Receives water out of the Van Brimmer Canal system. The Van Brimmer Canal gets its supply of water from Upper Klamath Lake through the Klamath Irrigation District system. The date of the contract is October 24, 1922.

Pine Grove Irrigation District. Receives water out of the A-Canal (Klamath Irrigation District system). The date of the contract is June 19, 1936.

Colonial Realty Company-Westside Improvement District. Receives water out of the Tulelake Sump and at the end of the J-1 lateral. The District was incorporated into Tulelake Irrigation District as an improvement district. The date of the contract is October 20, 1936.

Plevna District Improvement Company. Receives water out of the Klamath River below the Link River Dam. The date of the contract is April 1, 1940.

Emmitt District Improvement Company. Receives water out of the Klamath River below the Link River Dam. The date of the contract is December 1, 1947.

Midland District Improvement Company. Receives water out of the Klamath River below the Link River Dam. The date of the contract is February 2, 1952.

Poe Valley Improvement District. Receives water out of the Lost River below Harpold Dam. The District is highly dependent on return flows from the Klamath Irrigation District system in Poe Valley. The contract does not mention where the water is to come from, only that it will be made available in the Lost River. The date of the contract is July 20, 1953.

Ady District Improvement Company. Receives water out of the Klamath River below the Link River Dam. The date of the contract is August 5, 1954.

Klamath Basin Improvement District. Receives water through the Klamath Irrigation District system. The date of the contract is April 25, 1962.

Miscellaneous Warren Act Contracts. This group of contracts are scattered throughout the Project and get their water supply from the Lost River and Upper Klamath Lake/Klamath River. Some of the contracts have been turned over to Klamath Irrigation District to administer. Contract dates range from 1915± to 1960±.

Third Priority of Use Within the Project (Class C)

The first group of water users that would need to be shut off in the event of water shortages would be the temporary water rental contracts. Rental water is sold to individual farmers on an "if and when available" status. The Klamath Irrigation District and Tulelake Irrigation District both have clauses that allow them to sell rental water. In addition, Reclamation has rental contracts with users in the P-Canal and the Lost River areas.

Execution Plan

In the event that there was insufficient projected supplies of water available within the system from the Klamath River, the following actions would be taken:

March 10. If necessary, on this date or before, letters will be sent to all water users advising them that Reclamation can expect a deficiency in supplies of irrigation water and that sales of rental water may not be allowed pending the outcome of the April 10 meeting and April forecasts. Also, at this time, separate letters will be sent to the Class B users advising them of our intent to limit their use of water should supplies fall below Reclamation's projections. The letter would also request that the appropriate portion of Exhibit 1 be completed by the respective districts and returned to Reclamation no later than March 26.

April 10. On or before this date an allocation projection meeting would be hosted by Reclamation in which the district manager and the board chairman from each district would attend. Reclamation would have the information from Exhibit 1 compiled and a proposed allocation available. This would become the basis for discussions, potential revisions and efforts to arrive at an equitable reallocation of available supplies. Factors such as reduced acreages, crops that use less water, farming practices that reduce water use, and other water saving measures would be taken into consideration. The final projected allocation would be determined from this meeting.

May 10. Reclamation would revise the allocation using percentages based on changes in storage and run-off that occur between April 1 and May 1 and send the data to the districts via certified mail.

In the event that the cooperative effort discussed in the April 10 meeting reaches an impasse, the following plan would be followed:

The sufficiency of the water supply would re-evaluated by the Project and, if found insufficient to meet secondary demands, Klamath Irrigation District, Tulelake Irrigation District and Klamath Drainage District, would be notified to stop or limit deliveries to the specified Class B users under their delivery control points. In addition, the Project would notify other specified Class B users to stop or limit delivery of irrigation water.

Letters would be sent to the Class A Users assigning them an acre-foot allocation and flow schedule for the balance of the irrigation season.

The above described measures would remain in effect until the Bureau declared a water supply status capable of meeting all contractual commitments.

Section III, Part 1

Biological Opinion regarding Operation of the Bureau of Reclamation's Klamath Project and its Effects on the Bald Eagle

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1.0 STATUS OF THE SPECIES /CRITICAL HABITAT

1.1 Species Description and Life History

The bald eagle is a generalized predator/scavenger primarily adapted to edges of aquatic habitats. It weighs approximately 12 pounds and has a wingspan of 6-7 feet. Its primary foods, in descending order of importance, are fish (taken both alive and as carrion), waterfowl, mammalian carrion, and small mammals. The species is long-lived, and individuals do not reach sexual maturity until 4 or 5 years of age. Bald eagles nest in large trees near and usually within sight of large bodies of water. Nests are constructed of large sticks, are typically 4 ½ feet wide and 3 feet deep, are used year after year and may attain weights of several hundred pounds. The nest occasionally becomes large enough and heavy enough to break off supporting limbs. Often eagles have an additional alternate nest in their territory (Stalmaster 1987). They can occupy nesting territories and nests for decades. Eagles generally mate for life but will replace lost mates readily. Eagles lay an average of 1-3 eggs and if no unusual circumstances exist, all hatch. If adequate prey is not available during brooding only the largest nestling may survive (Kaufman 1996). Young fledge in approximately 10 - 12 weeks but may take another 4 weeks to become proficient at flight. Within several weeks of flight proficiency the young are generally self sufficient and can find food on their own, though they often remain near their parents nesting territory.

Bald Eagles require year-round access to food. Bald eagles that occupy nesting areas without winter access to food migrate from nesting areas to wintering areas with accessible food and night-roosting shelter for thermo-regulation and protection from disturbance. Immature or non-breeding adults often spend a longer period at wintering areas than do breeding adults.

The bald eagle once nested or wintered throughout much of North America near coasts, rivers, lakes, and wetlands.

1.1.1 Bald Eagle Life History in Pacific Recovery Area

Bald eagle nests in the Pacific States Recovery Area are usually located in uneven-aged stands of coniferous trees with old-growth forest components and are generally located within one mile of large bodies of water. Factors such as relative tree height, diameter, species, form, position on the surrounding topography, distance from water, and distance from disturbance appear to influence nest site selection. Nests are most commonly constructed in Douglas-fir, Sitka spruce and Ponderosa Pine trees, with average heights of 116 feet and diameters of 50 inches at breast height (Anthony et al. 1982, cited in USDI et al. 1996). Bald eagles usually nest in the same territory and use the same nest year after year. Availability of suitable trees for nesting, foraging and roosting is critical for maintaining bald eagle populations.

Quality of wintering habitat is tied directly to local food sources and characteristics of the area that promote bald eagle foraging. Wintering bald eagles may roost communally in single trees or large forest stands of uneven ages that have some old-growth forest characteristics (Anthony et al. 1982, cited in USDI et al. 1996, Dellasala et al.1998, Keister et al. 1987, Keister and Anthony

1983). Some bald eagles may remain at their daytime perches through the night but bald eagles often gather at large communal roosts during the evening. Communal night roosting sites are traditionally used year after year and are characterized by more favorable microclimate conditions. Roost trees are usually the most dominant trees of the site and provide unobstructed views of the surrounding landscape. They are often in ravines or draws that offer shelter from inclement weather (Keister 1987). A communal night roost can consist of two birds together in one tree, or more than 500 in a large stand of trees. Roosts can be located near a river, lake, or seashore and are normally within a few miles of day-use areas but can be located as far away from water as 17 miles or more. Prey sources may be available in the general vicinity, but close proximity to food is not as critical as the need for shelter that a roost affords (Stalmaster 1987).

A detailed account of the taxonomy, ecology, and reproductive characteristics of the bald eagle is presented in the Pacific States Bald Eagle Recovery Plan (USDI 1986).

1.2 Population Dynamics

In the 1900's the nation's bald eagle population underwent an extreme decline, due to losses at all life stages. In 1963, a National Audubon Society survey reported only 417 active nests in the lower 48 States. The species suffered population declines throughout most of its range, including Oregon and California, due primarily to habitat loss, shooting, and environmental pollution (U.S. Fish and Wildlife Service [USFWS] 1986). Adults were lost through shooting, poisoning and electrocution and eggs were lost through eggs breaking during incubation. Current estimations in the lower 48 United States indicate the breeding population exceeded 5,748 pairs in 1998.

1.3 Status and Distribution

On February 14, 1978, the bald eagle was federally listed throughout the lower 48 States as endangered except in Michigan, Minnesota, Wisconsin, Washington, and Oregon, where it was designated as threatened (USDI 1978). In 1995, (except in the above mentioned states where it was already listed as threatened), the bald eagle had recovered significantly to be down listed from endangered to threatened (60 FR 36000, July 12, 1995). The 1978 listing was the result of a decline in the bald eagle population throughout the lower 48 States. The decline was largely attributed to the widespread use of DDT and other organochlorine compounds in addition to destruction of habitat, illegal harassment and disturbance, shooting, electrocution from power lines, poisoning, and a declining food base.

Current range-wide trend data for the bald eagle indicates increasing populations. It is estimated that in the lower 48 states the breeding population exceeded 5,748 pairs in 1998. The recovery has been broadly distributed across the range of the bald eagle. For example in 1984 the 6 states of Florida, Wisconsin, Michigan, Minnesota, Washington and Oregon held 74 percent of the total breeding population. In 1998 that percentage was reduced to 54% (USDI 1999). As their range-wide viability improved, the bald eagle was proposed for delisting in 1999 (USDI 1999b). The Service is considering concerns related to monitoring of nests and protection of wintering areas and other bald eagle issues at this time. No date has been projected for the removal of the bald eagle from the threatened species list.

In the Pacific States Recovery Area, the number of occupied territories has consistently increased since 1986 and exceeded 800 beginning in 1990 when 861 territories were reported. The area has exceeded 800 for the last 10 years. The Pacific States Recovery Area held 1,480 pairs in 1998 (USDI 1999b).

There is no critical habitat designated for bald eagles and therefore this opinion will not examine critical habitat or effects on critical habitat.

1.4 Conservation Needs

1.4.1 Range-Wide

Each of the five regional bald eagle recovery plans set specific recovery goals for the regions. The recovery plans contain several numeric targets for numbers of breeding pairs in the region, productivity rates, and other criteria for delisting. The Service reviewed the status of bald eagles in 1999, and determined that most of the recovery criteria had been met or exceeded, and that bald eagles had, in general increased throughout each recovery region and bald eagle numbers had decreased in no sizable areas.

Some threats remain, including, but not limited to: contamination from toxins and lead associated with waterfowl hunting, habitat loss or impairment from increasing of human use in bald eagle habitat, incidence of disease, including new diseases for which causes or treatments are not understood, and injury from wind turbines. Long-term survival of bald eagles depends on the relationship of these threats to the reproductive rate and individual survival of eagles. Despite these and other threats, bald eagle numbers are generally increasing or stable, and as such, no additional specific conservation needs were identified in the Service's 1999 proposed rule to delist bald eagles. The proposed rule, however, clearly indicates the stable or increasing trend for bald eagles was caused by existing and past conservation efforts to avoid or reduce known threats. A reduction in existing conservation efforts, then, would be expected to cause a reduction in the stable or increasing population trend.

In addition, literature indicates that survival of adult birds is very important to population maintenance. A population can have a maximized reproduction rate, but if survival of the breeding adults is low, extinction can still occur (Grier 1980). Stalmaster (1987) felt that due to the longevity of bald eagles, the importance of their reproduction rate was secondary to keeping individuals in the existing breeding population alive.

Along with maintaining low contaminant levels, one of the keys to both adult survival and successful reproduction is the quantity and quality of available food during winter(Stalmaster 1987, Stalmaster and Kaiser 1997, Swenson et al. 1986). Winter is the season that exerts the highest stress on eagles and can sap energy stores and body fat for thermo-regulation. Particularly during winter stress, without adequate food resources eagles may starve. Starvation occurs most commonly in young birds that are less efficient at foraging (Stalmaster and Gessaman 1984). Winter also immediately precedes the breeding season. Therefore eagles need to find enough food to ensure adequate physiological condition to initiate breeding. Breeding is often initiated in late

winter when nightly temperatures may dip below freezing, so it is imperative that eagles survive winter in excellent physical condition to withstand the rigors of breeding. This relationship of winter food to eagle survival and reproduction is one of the main reasons that wintering populations were singled out in the Pacific States Bald Eagle Recovery Plan as needing protection and monitoring.

As previously described, wintering habitat requires a combination of available food, low disturbance, with appropriate roosting nearby. Protection of wintering areas requires protection of foraging and roosting habitat and assuring the two remain in relatively close proximity to one another.

1.4.2. Pacific Recovery Area

The Pacific States Bald Eagle Recovery Plan (USDI 1986) established recovery population goals, habitat management goals, and 47 management zones (i.e., recovery zones). The Bureau's proposed project is located within this Recovery Area and the Klamath Basin Recovery Zone (22) that includes a portion of Northern California. The Pacific States Bald Eagle Recovery Plan (Recovery Plan) described these specific criteria for the Pacific Recovery Area (PRA) as necessary for delisting :

1. The PRA should have a minimum of 800 nesting pairs;
2. PRA pairs should produce an annual average of at least one fledged young per pair, with an average success rate per occupied territory not less than 65% over a 5-year period;
3. PRA population recovery goals must be met in at least 80% of the management zones (e.g., 38 out of 47 recovery zones); and
4. wintering populations greater than 100 individuals should be stable or increasing.

Wintering areas and the eagles that use them are critically important to recovery and long- term maintenance of the species. The Recovery Plan states that before delisting "Wintering populations greater than 100 individuals should be stable or increasing" (USDI 1986). The Service's 1999 proposed rule to delist bald eagles did not state that the wintering criteria had been met, but rather indicated that winter populations "...are difficult to assess because concentrations are dependent on weather and food supply and thus can be quite variable from year to year" (USDI 1999). The Pacific States Bale Eagle Recovery Plan is now seventeen years old, but the necessity of protecting wintering areas for bald eagle conservation is still widely held. For example, the Bald Eagle Working Group for Oregon and Washington (Working Group) expressed concern in response to the Service's proposal to delist bald eagles, stating "...stable or increasing wintering population has not been confirmed" (Leighty 1999). In the same letter, the Working Group stated that even state and federal laws might not be currently adequate to ensure protection for wintering populations and communal roost areas even on state and federal lands. Uncertainty remains that the Recovery Plan delisting criteria have been achieved, and Working Group's concerns for this recovery area underscores the importance of maintaining and protecting the wintering area and population in the Klamath Basin.

During the late fall and winter, as many as 1,100 bald eagles from throughout the Pacific Northwest, western states and Canada migrate into the Basin (McClelland 1994, Keister 1987). Some evidence suggests immature and subadult eagles linger in or near Lower Klamath NWR for a few months after the bulk of the breeding eagles have dispersed to nesting areas. Lingering on wintering grounds, especially Lower Klamath NWR, represents an important opportunity for eagles to feed where food is plentiful and harassment from other eagles is low.

Given the large number of bald eagles wintering in the Lower Klamath NWR, maintenance of the wintering area for continuous occupation of large numbers of bald eagles should be considered part of the conservation needs of the bald eagle both in the Pacific Recovery Area and in North America.

1.5 Effects of the Proposed Action

Bald eagles that nest in the Klamath Basin may be adversely affected by the proposed project. The large wintering population (up to 1100 bald eagles) is also likely to be adversely affected. The most significant effects of the proposed action are likely to occur to wintering bald eagles during years when water deliveries to Tule Lake and Lower Klamath NWRs are lower than necessary to maintain adequate waterfowl numbers as prey for eagles.

2.0 ENVIRONMENTAL BASELINE

2.1 Status of the Species within the Action Area

This section addresses historic and recent past operations of the Klamath Project. In some years, up to 117 pairs nest and 1,100 individual bald eagles winter in the Klamath Basin. Since 1990, about 200-1,100 bald eagles wintered in the Klamath Basin. In 2000, the Klamath Basin Recovery Zone contained 117 occupied breeding sites, exceeding the Recovery Plan population goal of 80 for the zone (USDI 1986). The Klamath Basin breeding population is approximately 30% of the nesting bald eagles in Oregon Recovery Zones and the small area of Washington included in the Columbia River Recovery Zone.

The 1986 Pacific States Bald Eagle Recovery Plan (Recovery Plan) designated 47 smaller zones to facilitate recovery and planning efforts. The Washington and Oregon zones (22 total) were addressed in the Working Implementation plan for bald eagle recovery in Oregon and Washington [WDW 1996 (Implementation Plan)]. The project area is within the Klamath Basin Zone of that planning document. General goals for the Klamath Basin Zone are outlined in the Implementation Plan.

Bald eagle populations in the Klamath Basin include 3 groups: breeding adult pairs, non-breeding immature and sub-adults, and wintering birds, including many migratory adults which breed hundreds of miles north and west of the Klamath Basin. Following is a brief discussion of the biology and status of each of these groups in the Basin.

The Service's biological opinion of the effects of the proposed action on the Lost River and short nose sucker includes a Reasonable and Prudent Alternative that would avoid jeopardizing the continued existence of these species. The adoption of the Reasonable and Prudent Alternative would not change the types of effects on wintering bald eagles, but would likely increase the frequency of those effects.

2.1.1 Adult Breeding Pairs

One hundred-seventeen nesting pairs occur in the Klamath Basin including on or near Upper Klamath Lake, Gerber Reservoir, J C Boyle Reservoir, the Klamath River, and the Lost River. Because bald eagles depend on water bodies for a food supply most of these nests could be affected by Reclamation's water deliveries to the Klamath Project. Over the past 5 years Oregon and Washington reproduction rates per occupied site has been 0.97 and 0.86 respectively (Isaacs and Anthony 2000). These rates are close, but do not meet the goal of 1.0 young per year per occupied site set by the Recovery Plan. The five year average success rate per occupied territory is 61% in Oregon and 55% in Washington also fall short of the goal of not less than 65% over a 5-year period (Isaacs and Anthony 2000). Roughly half of the breeding pairs nest near Upper Klamath Lake. Four nesting pairs hold territories on or near Gerber Reservoir. The status of adult breeding pairs and their habitat on these two areas, and the potential nesting area on Clear Lake is discussed below. Many of the other nesting pairs use Gerber and Upper Klamath Lake or other parts of the action area affected by the proposed operations of the Klamath Project and effects on those nesting bald eagles would be similar, but less severe than those described for the Upper Klamath and Gerber Reservoir. Bald eagles do not have nesting territories in some portions of the action area, and those areas are not discussed in this section.

2.1.1.1. Upper Klamath Lake

Greater than 50 eagle nesting territories occur on or near Upper Klamath Lake. Eagle reproduction at Upper Klamath has been within the typical range (1.06) for this recovery zone the past few years (Issacs 2000). Many of Upper Klamath Lake nests occur on Forest Service lands near Upper Klamath Lake National Wildlife Refuge. The eagles nesting in these territories use the Recreation and Crystal Creek areas to forage for prey. Aerial photographs of this area show hardstem bullrush encroachment into many of the small channels and pools used by eagles (R. Hardy, pers. comm.) This also appears to be happening in the areas near Hank's Marsh near Highway 97 on the east side of the lake and near Eagle Ridge (R. Opp, pers. comm.). While marshes generally exhibit high diversity due to the variety of microhabitats, as bullrush expand, foraging areas and prey production for piscivores are reduced.

The reasons bullrush is increasing are not known. Bullrush expansion is naturally limited by water depth and generally dependent on seeds for propagation. The establishment of the Klamath Project and the maintenance of the lake below natural, pre-Project levels may have contributed to conditions favorable to expansion, but siltation and increased nutrient loads enabled by operation of the Project may also have played a role. Bullrush expansion caused a loss of shallow, open water favored by eagles for foraging. The reduced foraging areas near nests and may push eagles

into channels used more heavily by recreationists. The likely increased occurrence of incidental harassment would reduce foraging success during the critical stage of raising young.

Enhancement and restoration of natural wetland habitats has occurred in Agency Ranch and the Wood River area and have made the upper Basin more attractive to waterfowl. This may have resulted in a slight increase in prey for eagles nesting near those areas during the spring and summer. In late fall and winter as ice covers the Agency Ranch and Wood River wetlands the waterfowl move lower in the Klamath Basin to open water.

2.1.1.2. Gerber Reservoir

Two known nesting territories occurred at Gerber Reservoir in the 1992 and were noted in subsequent biological opinions on Bureau operations. Since then, two additional territories have been established in the area of Gerber Reservoir (Isaacs 2000; G. Sitter, pers. comm.). The increase in nesting at Gerber Reservoir is likely the result of increasing number of eagle pairs in the basin, 6 years of high reservoir levels and possibly "packing" of available habitat.

Since the addition of two nests, the reproductive rate of all four nesting territories has been considerably lower (Issacs 2000) than the rate of 1.0 young per occupied site per year Recovery Plan criteria. From 1986 through 1989, the Gerber nests averaged 1.25 young per year. From 1990 through 2000 the nests averaged 0.43 young per nest. The nests were monitored in 1991 because of concerns over effects of the low reservoir levels and the Service was considering a supplemental feeding program. No young were produced in 1992 and no supplemental feeding program was implemented. Successful eagle reproduction at Gerber Reservoir might be influenced by competition for a shrinking forage resource if Reservoir levels were lowered (Bureau of Land Management, 1992).

2.1.1.3 Clear Lake

No known bald eagle breeding territories occur around Clear Lake. Currently, eagle use is limited to foraging by eagles that nest in nearby areas and migrating birds, especially in dry years. With the expanding population of eagles in the Klamath Basin and limited foraging territories, it is possible that eagles may attempt to establish a foraging territory near Clear Lake.

2.1.2 Breeding Season Use of the Klamath Basin by Non-breeding Adult and Immature Bald Eagles

The Klamath Basin provide summer and winter habitat for nonbreeding adult and immature eagles from local populations and from outside the Basin and other recovery zones. Wintering is discussed below (section 2.13). The number of non-breeding adults and immature bald eagles that use the Klamath Basin in the summer is unknown. Due to the dominance of territorial mated pairs, non-breeding adults and immature eagles are likely to have limited opportunities for using prime foraging areas in the Klamath Basin.

2.1.3 Wintering Eagle Status in the Klamath Basin

The Klamath Basin harbors one of the largest winter concentration of bald eagles in the lower 48 states and regularly supports 500 to 1,100 birds. In most winters 80 to 90 percent of the eagles in the Basin forage on Lower Klamath NWR (KBNWR, unpublished data). The highest recorded number of bald eagles wintering on Lower Klamath NWR is 950. The eagles that winter in the Basin nest in Canada and many Northwestern States such as, Oregon, Washington, California, and Arizona (Frenzel, 1985; KBNWR, unpublished data). Mid-winter eagle counts have shown approximately 40% of all California eagles winter on Tule Lake and Lower Klamath NWR (Detrich 1986).

As discussed above, waterfowl are the main food source of wintering bald eagles in the action area. Table 1 shows recent habitat used by waterfowl prey areas and water use required to maintain those habitats on the Lower Klamath NWR. The current trend in the predictability, abundance, and availability of waterfowl that the wintering eagles in the Basin depend cannot be described as stable.

Table 1. Habitats important to waterfowl and bald eagles on Lower Klamath National Wildlife Refuge in 1992, 1994, and a year of full water delivery (planned for 2001).

Year	**Permanent wetland Acres**	**Seasonal wetland[1] Acres**	**Acres of Small grains[2]**	**Total wetland Acres**	**Acre-feet of Water need/use[3]**	**Peak fall waterfowl**	**January waterfowl**	**January eagles**
2001 Habitat Plan[4]	11,163	8,161	4,476	19,324	68,973	up to 1.8 M	up to 340K	up to 958
1992	5,005	6,258	3,986	11,263	43,930	804K	3,750	51
1994	9,104	4,955	3,648	14,059	50,974	607K	166,000	465

[1] Flooded prior to October 31. Other wetlands would flood after this date.
[2] Flooded December, January, and February.
[3] Water need/use May-October for permanent and seasonal wetlands and Dec-Feb. for winter irrigation of grain.
[4] Water management planning assuming full water delivery to Lower Klamath NWR sufficient to meet the refuge's legislated purposes for a full range of endemic species.

Eagles from northern areas winter in the Klamath Basin because of concentrated food sources and nearby roosting habitats. Eagles from the south come north to capitalize on the same resources. Data suggest that degraded weather and prey conditions in other regions may cause eagles to move into the Basin to feed on waterfowl and rodents. The combination of abundant food and roosting habitat is so unusual and important that its protection was cited as the reason the Bear Valley National Wildlife Refuge was established in 1978. Bear Valley NWR is one of the few refuges or sanctuaries of its kind in the United States.

Large winter concentrations of eagles in the Klamath Basin have been noted as early as the 1930's when up to 200 eagles gathered just at Tule Lake to feed on waterfowl (Worcester 1934 *in* Weddell et al. 1998). Bald eagles have likely been congregating in the Basin to winter for hundreds of years to feed on waterfowl as millions of ducks and geese migrate through this narrow point of the Pacific Flyway. Telemetry data suggests that like waterfowl, eagles follow traditional migration paths when dispersing from breeding areas to wintering areas (Hunt et al. 1992). Although some of these natural paths may be similar to flyways for waterfowl, the eagles are not necessarily following waterfowl. The large number and concentration of eagles found the Klamath Basin clearly indicate the area is a rich source of food with adequate winter roosts, and the eagles depend on it as a wintering area. This dependence may have increased with the recent loss of the large salmon runs that eagles depended on in the past (Bennetts and McClelland 1997).

Before the establishment of the Klamath Project wintering waterfowl were spread out over the entire Basin and were much less restricted in their choice of feeding and loafing areas. The Klamath Project significantly reduced the Basin's wetlands by draining and "reclaiming" them. Through these actions an estimated 70% of the Basin's wetlands were lost. This resulted in most of the potential waterfowl habitat, especially habitat available during freezing conditions, to be concentrated on the Tule Lake and Lower Klamath NWRs. Project operations also make those areas completely dependent on Reclamation's management of Upper Klamath Lake levels and water deliveries to irrigation districts for water to manage the remaining wetlands.

Reclamation's irrigation deliveries throughout the Project area eventually reach Lower Klamath and Tule Lake after use as irrigation on agricultural lands. Reclamation also allows some direct water deliveries from Upper Klamath Lake and the Klamath River to the Refuges. These deliveries in turn provide water to flood wetlands, stubble fields and deep water areas on the Refuge. This habitat then becomes a resting and feeding area for millions of southward migrating waterfowl passing through this portion of the Pacific Flyway. When water is available during the growing season to allow development of seasonal wetlands and flooded grain fields, hundreds of thousands of the migrating waterfowl stay through the winter and provide food for wintering eagles. Later in the winter, water is used to flood agricultural land on Refuge lease lands and neighboring private lands (Klamath Drainage District). This late winter flooding creates diverse and changing habitats that attract swans, geese and early duck migrants coming north to breed. Waterfowl stop to rest and stage for continued northward migration. In years that this northward migration occurs in February, the Northbound arrivals increase the numbers of dwindling overwintering waterfowl and bolster the food source for eagles. The late winter flooding also pushes small mammals to the surface where they provide an additional source of prey for wintering eagles as waterfowl numbers may be declining.

A major component to the eagle's efficient exploitation of abundant food resources in the Klamath Basin is available roosting areas. Keister (1983) identified five main winter roosts that supported the large number of wintering birds in Klamath Basin. The largest roosting area, Bear Valley National Wildlife Refuge, is near Worden, Oregon. The Mount Dome roost is six miles south of Lower Klamath in California. The Three Sisters roost is six miles south of Mt. Dome in California. The Caldwell roost is 11 miles south of Tule Lake and the Cougar roost is one mile south of the Caldwell roost in Lava Beds National Monument, California. The Bear Valley roost

has been occupied by as many as 400 eagles (Dellasala et al. 1998). Historically these roosts were used in conjunction with 3 main feeding areas; Lower Klamath NWR, Tule Lake NWR and private lands of the Klamath Drainage District adjacent to the refuges. The roost areas are all close to those feeding areas and the eagles shift roost preferences to save energy in flight time as prey location shifts.

The primary prey base for wintering eagles in the Klamath Basin is waterfowl. The species most often consumed are mallards, pintails and wigeon. Waterfowl that are injured during the hunting season are a significant source of easy prey for the eagles. Also, waterfowl that are stricken with avian cholera are easily captured or scavenged (Frenzel 1985). Small mammals that leave flooded burrows become important as agricultural lands are flood irrigated in late winter (Frenzel 1985 in Keister 1987). All of these factors; water management, number and distribution of waterfowl, and weather determine the size and availability of food for wintering eagles during the stressful winter season.

Traditionally all three feeding areas (Lower Klamath, Tule Lake and Klamath Drainage District lands) were used each year by wintering bald eagles (Keister, 1987). Since 1984, data shows a steady and prominent decline in eagle foraging on Tule Lake (KNBWR unpublished data) that is strongly correlated with a decline in waterfowl use. This decline and a possible cause are noted in the Bureau's draft 2001, BA "...the decline in waterfowl numbers appears to be related to the loss of extensive areas of emergent wetlands." (USDOI, Bureau of Reclamation 2001). Other factors include: siltation of deepwater habitats (approximately ½ inches lost of the water column per year since 1959 (KBNWR unpublished data); insufficient water to produce seasonal marshes in the fall; and stabilized water levels on Tule Lake that reduce the aquatic productivity for waterfowl foraging. In addition, the Kuchel Act of 1964, (an Act which specifies agricultural management on the refuge) was initially interpreted as restricting wetlands to the present Sumps and sought to maintain water levels with little fluctuation. It became apparent by the early 1990's that the result of that management was degraded wetland habitat conditions reducing waterfowl and eagle abundance. Experimentation of alternate management for Tule Lake has resulted in significant use by both waterfowl and eagles.

Some of these factors have been influencing conditions at Tule Lake since the 1960's, including static water levels in Tule Lake; limited or unpredictable water deliveries are more recent management problems. The more recent, observable decline in waterfowl and eagle use, coming some years after the onset of the trends in siltation and habitat changes, may be the result of a lag in changes of traditional behavior patterns. Waterfowl, as with most wildlife, often continue to follow migrational behavior patterns even when those behaviors are not as beneficial as they once might have been. That can result in behavior changes being observed several years after the habitat changes. Whatever the exact mechanism, the long- term decline in waterfowl and eagle use of Tule Lake is well documented.

The secondary impact in the reduced quantity and quality of habitat on Tule Lake has been a shift of waterfowl use to Lower Klamath in the fall and a concentration of the remaining overwintering waterfowl on Lower Klamath NWR. This has been accompanied by a steady increase in the concentration of eagles on Lower Klamath NWR. In the last 6-8 years less than 10% of the eagles

in the Basin are counted on Tule Lake (unpublished KNBWR). The data shows clearly that Tule Lake has largely lost it's historical role as one of the primary feeding areas for wintering eagles. This has reduced the number of traditional feeding areas for the very large concentration of eagles from three to two.

An indication that this trend could be reversed given time and water is seen in the results from research at Tule Lake. A recent study by the University of Washington on seasonal draw downs of water found that carefully timed draw downs effectively promoted wetland plant diversity (Washburn, 2001). Also, recently a pilot project to monitor waterfowl use of short-term seasonal wetlands at Tule Lake found waterfowl response was immediate and substantial. Increased eagle use of these temporary wetlands has also been observed. The research targeted within-season migration, not year to year migration, but demonstrates the capacity of eagles to adapt to new concentrated food sources. Information from research and this pilot program will likely be used to increase NWR waterfowl habitat over the long term. Early results are promising.

This restoration or enhancement is consistent with the Recovery Plan (USFWS 1986). The Plan lists it as a specific task in its step-down narrative:

> "1.3122 Enhance Waterfowl Habitat On Bald Eagle Wintering Areas.
>
> Because of their importance both as a primary and secondary eagle food source, waterfowl populations should be encouraged to use areas of open water where bald eagles winter. A small population of waterfowl can support many wintering eagles. Waterfowl habitat management can include water level management and establishment of food plants , such as unharvested corn."

Cooperative lands and lease lands on Lower Klamath and the private lands of the Klamath Drainage District (KDD) adjacent to the refuge also provide another food resource for the wintering eagles. These lands are flooded in later winter to raise the soil moisture and control rodents. As the fields are inundated with water thousands of rodents are forced to the surface and are easy prey for eagles and other raptors (Keister 1987). It results in an important food source later in the winter when waterfowl numbers normally are declining. However, just like Tule Lake and Lower Klamath NWR the KDD lands rely on Reclamation for water to flood irrigate. The private lands also are under no requirement to flood fields. In recent years with the possibility of growing season water shortages the private land owners tendency has been to flood their lands earlier to utilize water before water shortages arise (D. Mauser, pers. comm.). Earlier flooding (during November- December) of these fields still increases rodent-prey availability, but then does not coincide with the January and February waterfowl shortages when eagles would benefit from an alternate food source.

The benefits of flooded fields, specifically in the Klamath Basin, was discussed in the Recovery Plan. The stepdown narrative outlined tasks to implement for recovery:

> "1.3124 Encourage Flooding Of Fields Where Appropriate, To Make Rodents Available To Eagles
>
> Flooding of agricultural fields for the purpose of rodent control provides an important food source for wintering eagles in the Klamath Basin. As many as 4,400 bald eagle use-days were recorded on one ranch in December 1981. Many farmers use flooding as an alternative to poisoning and thereby do not contaminate potential eagle food sources."(USFWS 1986)

Since flooding on private KDD lands depends on water availability and the willingness of private landowners to do so, Lower Klamath NWR should be considered as the only feeding area currently protected and (with adequate water delivery) a reliable feeding area for wintering eagles. The significance of the LKNWR is demonstrated by data from the last five years that show the area supports greater than 50% of all the wintering eagles found in the Basin, and harbors closer to 80-90% in most years.

However, Lower Klamath NWR is dependent on Reclamation for water delivery. In recent years with the change in lake levels, drier water years and concern for the needs of downstream resources, consistent, predictable and adequate water delivery for Lower Klamath NWR is uncertain. In four different years between 1992 and 2001 the Refuge has had their water supplies shut off or reduced.

Studies have shown that eagles move out of dispersed wintering areas when food becomes scarce (Swenson et al. 1986, Isaacs et al. 1996). The fluctuating numbers of eagles using the Basin may be the result of larger regional food scarcity moving larger than average numbers of eagles into the Basin in low food years. This behavior tendency and the geographic position of the Basin, suggests that in times of general food, weather or drought stress many eagles which may migrate to the Basin every year, rely on the Basin as a "safety net" during periodic, but widespread, declines of available food.

Drought conditions may be a factor in these shifting patterns. In January of 1992 the number of eagles in the basin reached a recorded high of 1,151 birds. 1992 and 1994 were also a years of peak eagle numbers, at a wintering site on John Day River about 250 miles to the northeast (Isaacs et al. 1996). The observations coming on the heels of a several year drought cycle suggests that regional droughts push eagles out of marginal areas to areas of greater prey abundance. These years are also those when Reclamation water deliveries to the refuge will be most at risk because of needs of primary water users. Therefore a combination of harsh years, reduced water deliveries, high numbers of wintering eagles and low or non-existent waterfowl populations would result in very high levels of adverse impacts to local and wintering eagles. This underscores the importance of maintaining and managing for the stability of the wintering eagle population in the Klamath Basin.

As recently as September of 2000, due to water shortages, Reclamation stopped delivery of water to the Refuge. This threatened the availability of water for fall waterfowl habitat reducing the numbers of waterfowl that would use the refuge. Refuge managers and agency executives

considered the possibility of closing the refuge to waterfowl hunters. A thunderstorm system brought additional water to Upper Klamath Lake, water was released into the system from Clear Lake and the hunting closure was averted.

2.2 Other Factors

A number of factors are known to impact bald eagles. They can be generally categorized as: (1) presence, abundance and seasonality of food resources; (2) winter roosts; (3) nest sites; (4) harassment and disturbance; and (5) poisons and contaminants. The most significant factors in the Klamath Basin are probably nest sites, winter roosts and food resources. The sections below generally discuss these factors. The specific relationships between these factors, the status of the bald eagle in the Klamath Basin, and the proposed project will be discussed in the "Effects of the Action" section of this opinion.

2.2.1 Food

The bald eagle has food habits that are very diverse. Given the availability of prey the most restrictive element in successful feeding is presence of large expanses of hunting areas (open water or land) that are undisturbed (Stalmaster 1987). Bald eagles pirate food from Ospreys, catch fish, small mammals and birds, and scavenge from waterfowl die offs and deer killed by vehicles. Eagles prefer fish especially during nesting if fish are available (Kaufman 1996).

In the Klamath Basin there are three major classes of prey which vary by season: (1) fish, breeding waterfowl, and small mammals available during the eagle breeding season; (2) concentrations of migratory waterfowl available to eagles during the fall and winter months; and (3) small mammals made available due to irrigation flooding during late winter months. Each of these forage classes is influenced by water management and irrigation practices.

Prey becomes available to bald eagles in two ways: (1) when the behavior of a live individual prey item makes it available for capture, such as a fish basking or feeding near the water surface; or (2) when the carcass of a dead individual is available on the ground, on ice, in shallow water, or floating at the water surface. In general, only a portion of dead prey is actually discovered and taken before it becomes unavailable through decomposition or is taken by other scavengers. The number of dead prey items is a function of the live prey population size, in that the larger the live population the more likely it is to have dead or dying members from injury or disease outbreaks.

At Upper Klamath Lake, important prey species during the nesting season include tui chub, blue chub and suckers (Frenzel 1984). Territorial nesting bald eagles in the Klamath Basin remain on or near their territories year round but do (particularly in cold early winters) benefit immensely from the winter feeding areas on Tule Lake and Lower Klamath. Recent restoration efforts on and near Agency Lake should contribute to higher numbers of nesting and loafing waterfowl until fall. These waterfowl provide some additional food for nesting adults and fledglings. In winter waterfowl abandon these areas and congregate on Tule lake and Lower Klamath.

Species composition of eagle prey at Gerber Reservoir has not been documented. The reservoir's fishery resource consists largely of introduced species such as crappie, perch, bass, and also includes rainbow trout and native suckers.

In the late fall and winter, resident territorial pairs and non resident eagles migrating to the area feed on the waterfowl streaming through this area of the Pacific flyway. Waterfowl are an excellent food source for eagles. It digests well because of its fat content and delivers more calories per gram than other foods. Fish are a much less efficient food source (Stalmaster 1987).

Waterfowl become food for eagles through several circumstances. Live and healthy ducks and geese can be pursued and killed by eagles but their success is limited (Griffin 1982, McWilliams et al. 1994). Waterfowl that are crippled or die as a result of hunting, but are not recovered by hunters, are a much easier source of food for eagles. Waterfowl also have outbreaks of diseases such as avian cholera when massed in large numbers over small areas. Waterfowl weakened or killed by cholera are readily captured or scavenged on by eagles (Griffin 1982). Weakened or compromised waterfowl that are more easily caught are a very important food source for young eagles with limited foraging experience. These eagles are able to hone foraging skills by practice and by observing older more proficient birds. The importance of easy prey for young eagles may be the reason that young eagles tend to arrive first and leave last in food rich winter feeding areas (KBNWR unpublished data, Griffin 1982, Zwank 1996). Young eagles have been found to be proportionately less common at low yielding feeding sites (Stalmaster and Kaiser 1997) A ready food source, available in the winter when foraging success is low and energy demand is high, is crucial to winter survival for eagles. Without an adequate food source eagles can die from starvation or hypothermia (Sherrod et al. 1976 in Stalmaster and Gessaman 1984).

In the Klamath Basin another important source of food in the late winter is small mammals. Agricultural fields are often flooded in late winter to reduce destructive crop pests living in the soil and to raise the soil moisture before the growing season. The gradual flooding of large fields forces small mammals out of burrows and makes them susceptible to waiting eagles and other raptors (Keister 1987, Frenzel 1985). The flooding can also attract and hold early arriving swans and ducks on their migration path north.

The eagle is considered to be a species that is limited by food supply (Griffin 1982, Stalmaster and Gessaman 1984). Food resources may be the most important resource influencing the life and evolution of the bald eagle (Stalmaster 1987). This factor in eagle management and its relationship to the conservation of wintering populations has not received the attention it deserves (Stalmaster and Gessaman 1984, McClelland et al. 1994). Food availability has been cited as regulating the eagle population on Amchitka Island, Alaska where as many as 90% of all eagles die of starvation before reaching adulthood (Sherrod et al. in Stalmaster and Gessaman 1984).

Food availability and abundance are what have produced several large wintering groups of bald eagles. Most of these wintering groups are made up of hundreds of eagles (Stalmaster 1987). All large winter congregations have in common an abundance of food, little human disturbance and roosting areas. The food is most commonly fish or waterfowl. Large congregations of eagles enhance individual survival by making food resources easier to locate and reducing search time.

(Stalmaster and Gessaman 1984, Knight and Knight 1983). Once eagle migration to wintering areas is complete, eagle numbers on wintering areas appear to have a strong correlative relationship with the amount of food available (Griffin 1982, Keister 1987, KBNWR unpublished data).

Food availability is also affected by the amount of disturbance to feeding eagles. Foraging areas need minimal disturbance from human activities (Stalmaster 1987, Stalmaster and Kaiser 1998). Eagles are large and not as adept as many birds at becoming airborne which may be one reason eagles tend to select areas to feed that gives them a large sight distance to watch for disturbance or predators. Areas that may have large amounts of food but lack the open areas necessary for security to feeding eagles are likely to receive little use (Stalmaster 1987).

In the past, artificial feeding has been mentioned as a possible temporary solution to compensate for reduce prey levels in the action area. Stalmaster (1987) mentions that Maine and Washington have conducted artificial feeding but the overall results are not clear. Marr et al. (1995) discusses bald eagles' use of domestic sheep carcasses and suggests that it be encouraged as appropriate. Artificial feeding should be viewed as an emergency measure and a responsibility that cannot be taken lightly. A situation which would call for artificial feeding would by definition be one in which birds are already stressed and once feeding was initiated it would have to be continued until the crisis is over. Artificial feeding also tends to further concentrate birds, habituates them to humans and leaves them even more vulnerable to disturbance and injury. Artificial feeding can also introduce birds to food sources not normally used and can result in conditioning them to unnatural foods or behavior. For these reasons artificial feeding should be an emergency last resort and should try to mimic, as closely as possible, natural foods and presentation.

The success of eagles and raptors in finding sufficient food in winter, storing body fat and maintaining good physiological condition is likely to translate into greater reproductive success (Newton 1979 in Stalmaster 1987). Since many of the eagles wintering in the Basin are from other areas, poor feeding conditions in the basin for large wintering eagle populations puts those birds at a reproductive disadvantage, when they return to their nesting territories.

2.2.2 Roosts

Even though the primary reason eagles concentrate in areas during the winter is food abundance, the birds also require appropriate roost areas near the food sources (Keister et al. 1987, Stalmaster and Gessaman 1984, Stohlgren 1993). They provide important protection from harsh weather and low temperatures and may also allow for social learning of food sources between birds within the roost (Knight and Knight 1983). Roosts located in coniferous forests provide shelter in the winter that is unavailable in deciduous trees that have lost foliage. In the winter, eagles will fly past lesser roost areas to reach roosts that offer the microclimate characteristics necessary to conserve critical body energy (Stalmaster and Gessaman 1984). These characteristics are usually found in late seral or old growth forests that have large trees for perching and foliage shelter (Stohlgren 1993, Keister et al. 1987, Isaacs et al. 1996). The Basin provides several large roosting areas that have those characteristics, are near to the winter feeding areas on the Klamath Basin Refuges and are relatively undisturbed. The Klamath Basin is one of

only a few places in the region that has that unique combination (Stohlgren 1993, Keister et al. 1987).

2.2.3 Nests

In the Basin, bald eagles nest in large douglas fir and ponderosa pines usually very near rivers, lakes or reservoirs. Nests are used year after year as long as the nest tree remains stable. Eagles have been known to use the same nest for decades.

Nesting success, as measured by number of young fledged, is tied closely to food availability. In the winter bald eagles must obtain enough food to come into breeding season in good enough condition to commence nesting activities in early spring. There must be adequate food near the nesting territory to support 5 weeks of incubation, and provide food for nestlings and fledglings for about 4 months. Lack of food at various points in the breeding cycle may inhibit nesting attempts, cause abandonment of the nesting effort, or result in starvation of young.

Reproductive rates are also subject to several secondary variables. In some areas of their range weather is an important factor. Because bald eagles have evolved in and adapted to the climate of the Pacific Northwest, weather is not thought to normally be a factor in reproductive failure. Serious storms that occur at the time of incubation or hatching create an exception. Low productivity in the Klamath Basin in 1982 was believed to be the result of such storms (Frenzel 1984).

Contaminants can influence reproductive success. While several persistent contaminants have been documented in eagle body tissue in the project area, Frenzel (1984) concluded that contaminant levels had no significant effect on the area's bald eagle reproduction at that time.

Human disturbance is an important factor affecting nesting success at certain sites (See example in harassment and disturbance section below), but is not believed to be pervasive in the project area. None of these factors appear to impose serious limits on eagle populations at the present time. In the absence of the above secondary effects, prey availability is believed to be the primary limiting factor for nesting success of these eagle populations.

The Klamath Basin contains approximately 30% of the nesting bald eagles in the Oregon, Washington portion of the Columbia River Recovery Area. (Isaacs 2000). The number of young that can be produced in nesting territories and take advantage of the wintering areas in an area like the Klamath Basin contribute significantly to the recovery of the eagle in the Pacific Recovery Region. The Basin was an important core population producing young to fuel the general recovery in the region.

2.2.4 Harassment and Disturbance

Bald eagles can be very sensitive to human disturbance (Stalmaster 1998). There are certain times when the impacts of human disturbance can have more serious consequences than others. Disturbance particularly during nest establishment and incubation of eggs can result in

abandonment of nests or death of nestlings. Recent data from the Winema National Forest showed a doubling of fledging rate for eagle territories in a management area after it was closed to vehicular travel (Hardy 1998).

Foraging eagles often hunt the shallow areas of lake shores and riparian areas and these areas are also extensively used by fisherman and recreationists. The multiple demands on these areas can reduce the opportunity for eagles to forage and loaf. Stalmaster found that eagles feeding along the Skagit River reduced feeding by as much as 35% less than predicted due to recreational boating and hiking (1998).

Disturbance or flushing by eagles feeding in the winter can have a particularly negative effect on eagles by greatly increasing the energy needs during an already stressful period of time. Eagles seem to prefer roosting in undisturbed timber stands and feed in open areas, often on ice, that are some distance from possible sources of disturbance (Stalmaster 1998).

2.2.5 Poisons and Contaminants

Contaminants in the environment have had a significant impact on ~~to~~ bald eagles. One of the reasons that the eagle was listed as endangered in 1978 (threatened in Oregon) was due to very low reproduction rates and declining survival of adults. The leading cause for the low reproduction rate proved to be thinning of eggshells. The eggshells were then not able to support the normal pressure of incubating adults resulting in broken eggs. The eggshell thinning was caused by high levels of DDE (dichlorodiphenyldichloroethylene) in the egg shells. DDE is a metabolite of DDT an organochlorine pesticide in common use until 1972 (Frenzel 1985). This contaminant is bio-magnified in top predators and scavengers by their feeding on large numbers of contaminated prey items. Biomagnification of DDT in eagles has been as high as 4-fold in 120 days (Stickel et al. 1966, Chura and Stewart in Frenzel 1985).

Other poisons have caused, both intentionally and unintentionally, the deaths of golden and bald eagles. The compound 1080 (sodium fluoroacetate) and strychnine both used to reduce populations of coyotes and other mammals often had deadly consequences for non-target species including eagles (Terres 1982). Carbofuran, is a highly toxic, anti-cholinesterase insecticide that in granular form was also responsible for some bird deaths and secondarily toxic to scavenging or predatory birds. Intentional misuse of the insecticide has been linked to eagle deaths (Terres 1982) and it is now banned for use in its granular form. Several other anti cholinesterase pesticides have been implicated in eagles deaths (Environment Canada 2000) and are now either banned or under restrictive use to minimize potential for effects on non target species.

In the Basin, Frenzel conducted a study which evaluated the level of contaminants in eagle prey, eggs blood samples and body tissue. He found that wintering eagles did not have levels of DDT or DDE high enough to be associated with reproductive difficulties. Resident nesting bald eagles did exhibit moderate levels of DDE, PCB (Polychlorinatedbiphenyls) that suggested a reduced reproductive function (Frenzel 1985).

3.0 EFFECTS OF THE ACTION

Of the factors presented above, nesting food supply and wintering food supply are the factors most affected by the proposed action. The discussion below focuses on food supply for nesting and wintering bald eagles.

In general, the proposed action is likely to reduce the level of water in reservoirs during times of intensive bald eagles use during nesting and wintering, as compared to the current operation. Reduced water levels in reservoirs during nesting and wintering are likely to reduce bald eagle prey availability and prey productivity, and reduce the size of foraging areas, potentially increasing the distance between foraging areas and roosting areas. These environmental effects would likely increase competition between foraging eagles, reduce foraging efficiency, reduce fitness prior to migration to breeding grounds, potentially reducing breeding success of eagles that winter in the area.

The proposed action is complex and depends on many factors. The BA does not clearly indicate the amount of water that would be delivered to Lower Klamath NWR. As recently as September of 2000, due to water shortages, Reclamation stopped delivery of water to the Lower Klamath NWR as it had several times in the last decade. In contrast, the proposed action indicates the intent to deliver water adequate to keep Sump 1A, at Tule Lake NWR, at a minimum elevation of 4034.0 feet from October 1 through March 31 of each year. However, Sump 1A is predominately deep water habitat and has declined as a productive marsh in recent decades. As a contributor to waterfowl numbers useful to bald eagles, the sump alone is of minimal value. However, as described elsewhere in this opinion, delivery adequate for reestablishment of emergent wetlands on Tule Lake have shown great value as waterfowl habitat.

The sections below discuss details of the proposed action's effect on specific nesting and wintering areas within the action area.

3.1 Effects on Potential Nesting on Clear Lake National Wildlife Refuge

With the expanding population of eagles in the Klamath Basin and limited foraging territories, it is possible that eagles may attempt to establish a foraging territory near Clear Lake. Water manipulation of the lake would directly affect fish populations. Initially, temporary drawdowns may make fish easier to catch. However, fish population sizes may decrease during drawdown, and when the Reservoir is reflooded the prey would be less concentrated than before the drawdown. Eagles currently use Clear Lake as an opportunistic food supply, and if that type of use continues adverse effects would be unlikely. If foraging territories associated with nests are established on the Reservoir, the effects on the eagles with the territories would be more severe.

3.2 Effects on Nesting at Gerber Reservoir

Reservoir management could result in changes to the success of eagles feeding on fish in Gerber Reservoir. The relationship is not a simple one. Reservoir draw downs during dry years may result in temporary increases in prey availability because reduced water levels should cause

increased concentrations of fish populations and fish kills making foraging easier. If more drought years follow, reservoir levels will remain very low and fish populations will continue to decline or stabilize at a lower level resulting in an overall reduction of the prey base for eagles. Even when precipitation increases and reservoir levels rise, the remaining fish populations disperse into the increasing habitat, but at a much reduced density possibly further reducing the opportunities for capture by eagles. It may take one or more spawning years for fish populations to respond to increasing habitat as water levels rise. In either case, after an initial increase, forage availability is expected to be lower for some time following periods of reservoir draw downs and this is likely to result in a lower reproductive rate for nesting eagles for several years.

Another mechanism for impact is competition between eagles for limited prey during reservoir drawdawns. Eagles establish feeding territories on lakes and in bodies of water which they defend from other eagles. These territories generally consist of the more shallow area of the water body because fish are easier to locate and capture. Multiple territories around a reservoir are well known by territorial eagles and their boundaries are defended. If reservoir levels are reduced, then the foraging areas is also reduced, and thus the territories and the buffer areas between territories become smaller. Reduced area between territories and smaller territories are likely to increase the likelihood and intensity of territorial disputes between nesting eagles.

During the drought in the early 1990's there were two eagle pairs using Gerber for foraging. A monitoring report in 1992, by the Bureau of Land Management, identified two distinct foraging areas defended by the two nesting eagle pairs and raised the issue of shrinking habitat increasing the competition and lowering the success of the eagles (letter from B. Bail to Jim Bryant, April 28, 1992). Since that time two more eagles have established nesting territories near Gerber Reservoir and forage there. One was established in 1996 and another in 1997. With the addition of two more nests in the area, the reduction in surface area of the reservoir through lowered levels could be even more disruptive to nesting success.

3.3 Effects on Nesting at Upper Klamath Lake

Bald eagles nesting at Upper Klamath Lake are less likely than other territories to be adversely affected by the proposed project. Because the primary forage species at Upper Klamath Lake (tui chubs and blue chubs) are spring spawners, they should not be significantly affected by summer and autumn draw-downs. Eagle reproduction in this zone has been between 0.98 and 1.06 young per nest as a 5 year moving average, which is within the desired range of reproduction (Isaacs 2000).

However, there have been some habitat changes in the area that could affect foraging success. Near Upper Klamath Lake Wildlife Refuge, there has been a very noticeable loss of open shallow water near several eagle nesting and foraging territories (J. Hainline, pers. comm.; R. Hardy, pers. comm.). The loss is the result of the filling in of the fragmented bullrush marsh. As mentioned earlier the reason for this growth is not known but could be related to the change in depth of the lake from the historical levels. This loss of shallow open water for foraging and reduces overall foraging areas near nests. It could also reduce the areas used by both eagles and recreationists decreasing eagle foraging success and increasing energy demands. The proposed project does not

include reducing the lake level low enough in spring to facilitate vigorous growth of bullrush, but if that situation resulted due to water demand, it would contribute to the loss of foraging areas.

3.4 Effects on Wintering Bald Eagles in the Klamath Basin

As discussed above, the proposed action includes water delivery to wintering areas via operation of the Klamath Project. The water delivery affects wintering bald eagles because within the affected area, wintering bald eagles depend on waterfowl. Waterfowl depend on specific wetlands habitats. The more area covered by suitable wetlands, the greater the number, likelihood and duration of waterfowl use. Wetland habitat types and surface area depend on the amount of water delivered. Because of this series of relationships, the Service's analysis of effects of the proposed action on wintering bald eagles will examine bald eagle needs first in terms of waterfowl, then in wetland types and areas, and then the amount of water delivered.

Wintering areas that provide adequate food and areas free from harassment as feeding sites are possibly the most significant contribution to adult survival (Stalmaster 1987, Grier 1980, McClelland 1994). They provide an easy, low energy cost source of nutrition during times of seasonal stress. When combined with nearby roosting habitat that is protected from foul weather and harassment, the advantage to the fitness of the eagles is tremendous. It is especially valuable for immature bald eagles because when prey availability is low, immature eagles are likely to suffer the highest mortality rates (Stalmaster and Gessaman 1984).

The relationship between numbers of waterfowl and numbers of bald eagles in the Lower Klamath NWR is similar to the relationships found in other areas between eagles and food.
Keister et al (1987) found that "waterfowl populations on Lower Klamath was most important for predicting eagle use at that location". In addition, larger populations of waterfowl increase both the number of dead birds and the likelihood of dead birds from disease outbreaks (USDI and USGS, 1999). Disease outbreaks are less likely when waterfowl numbers are low.

Seasonal food sources and sites can be long term, such as the Klamath Basin or temporary sites such as local fish kills or ungulate die offs. An example of the temporary nature of some feeding sites can be seen in a study by researchers in Montana. From 1977-1993, R. McClelland studied the biology of autumn bald eagles feeding on kokanee salmon during a spawning run in Glacier National Park, Montana. Salmon had been introduced into the area in 1916 and the run of salmon had been noted to attract eagles as early as 1939. The run diminished and collapsed during his study and the population of eagles using the area diminished also. With the loss of this run and the collapse of many natural salmon runs in the Pacific Northwest (Bennetts 1997), McClelland felt that managers had ignored the importance of these food sources for adult survival and successful reproduction. He strongly recommended protecting even temporary feeding areas that can provide large amounts of food for eagles (McClelland 1994). The winter feeding sites in the Basin are natural, require little to sustain them and are the only large ones in the area. This means this valuable site would be relatively simple to perpetuate for long-term conservation of the eagle.

The relationship between the number of wintering eagles and the numbers and availability of prey has been the subject of several studies. One in north central Missouri at the Swan Lake National

Wildlife Refuge wintering eagles and their prey which was predominately waterfowl and fish found peak numbers of wintering eagles were directly related to peaks in waterfowl numbers (Griffin et al. 1982). This correlation even tracked temporary peaks in prey during the same season. In the winter of 1977-78 the average number of eagles was higher than the average for the first years of the studies. The author suggested several possible causes including the more severe than normal weather making foraging in other areas more difficult and a noted increase in the use of the refuge by waterfowl.

A similar positive correlation between availability of kokanee salmon and eagles was found for four of five years in a study on migrant bald eagles at Hauser Reservoir in Montana (Restani et al. 2000). Also a study on the Skagit River in Washington found the numbers of eagles present in the river area was a function of the availability of salmon carcasses (Hunt et al. 1992). Brown in 1993 found that as prey abundance increased the success rate of foraging eagles also increased (Brown 1993). The literature is clear that availability of food drives the number of eagles that a winter feeding area can hold and the success of their foraging efforts.

3.4.1. Relationship between Waterfowl and Bald Eagle Numbers at Lower Klamath NWR

Given the research described above and other on bald eagles and prey numbers, some threshold number of waterfowl are likely required to sustain the high concentrations of bald eagles documented to use Lower Klamath NWR. Waterfowl numbers below this threshold would likely sustain only relatively lower numbers of eagles. Waterfowl numbers above the threshold would sustain both relatively high and lower numbers of eagles.

Using data from the Lower Klamath NWR, the Service explored the specific relationship between bald eagle and over-wintering waterfowl numbers on Lower Klamath NWR to identify a threshold number of waterfowl that would sustain high concentrations of bald eagles frequently observed wintering there. This number will be referred to as the **?**threshold" or **?**waterfowl threshold number" in this opinion. January aerial counts of both eagles and waterfowl between the years 1981 and 2001 were plotted against each other and a simple linear regression performed. (Data and analysis are on file at the Lower Klamath NWR).

The resulting regression line was a relatively poor fit to the data ($r^2 = 0.2232$), due in large part to relatively higher variance in eagle numbers at high waterfowl numbers, as compared to variance in eagle numbers at lower waterfowl numbers. The pattern of the data was interpreted as likely evidence of prey swamping, a phenomenon where prey abundance surpasses predator need, so that food availability is no longer a factor in determining predator numbers (Craighead and Craighead 1956, Ricklefs 1983). The rise in the variance in eagle numbers appears to occur between 100,000 and 150,000 waterfowl. This suggests the waterfowl threshold number is between these numbers.

To more closely approximate this minimum, six additional scatter plots were produced, each including data up to, but not beyond a certain number of waterfowl (100,000, 125,000, 150,000, 200,000, 300,000, and 400,000). Each scatter plot was fitted with a regression line, and the resulting r^2 values compared. The plot of waterfowl < 125,000 had the highest r^2 value at 0.4087,

a substantially better fit. Each regression line was then tested for significance via ANOVA (H_0: ß = 0; a = 0.05), and the resulting p values compared. The plot of waterfowl < 125,000 had the lowest p value at @ 0.0008.

These results identified 125,000 waterfowl as the point before which bald eagles numbers are most strongly correlated with waterfowl numbers and after which prey swamping could explain decreases in the fit of regressions. Data analysis suggests 125,000 is the waterfowl threshold number necessary to provide adequate prey to maintain the high concentrations of eagles wintering on Lower Klamath described in the environmental baseline.

3.4.2. Verification of the Derived Waterfowl Threshold Number of 125,000

While waterfowl numbers are the main determinant of wintering eagle success, other factors such as ice cover and regional weather conditions can obviously influence prey availability and distribution in the Klamath Basin (Keister et al. 1987) and eagle immigration into the area. For example in January of 1988 when there were less than 125,000 waterfowl counted on Lower Klamath there were 597 eagles. However, there was an extremely large avian cholera outbreak that produced 8,000 dead ducks and geese in the peak wintering period. Thus, live waterfowl counts were low but prey items were abundant. Disease outbreaks, however cannot be predicted other than they are most likely to occur in larger populations.

Using studies on eagles we can check the approximation of waterfowl threshold against energy estimations for needs of wintering eagles. Stalmaster and Gessaman (1984) using lab measurements of captive eagles estimated that wild eagles feeding on salmon in northwestern Washington needed approximately 2,068 kilojoules of energy a day to provide their metabolic and biological energy needs under winter foraging and roosting demands. The energy value of various prey items, including Canada goose, coot and mallard was determined in a study by Stalmaster and Petner (1992). Assuming that eagles spend from the middle of December to the middle of March (approximately 90 days) in the Basin, they would require the energy equivalent of 8 geese, or 61 coots or 28 mallards per winter. This number is in close agreement with an estimate calculated from Stalmaster's (1987) approximation that an eagle would need 135 ducks a year (approximately 33 for 3 months) for energy needs.

Because of the competition and harassment between eagles, large prey items like geese, which may have the capability to provide more than the daily requirements for 1 bird, do not get spread equally among birds. Therefore a more useful estimate might be one medium prey item (mallard) every other day or so. That would be approximately 30 to 45 prey items a winter. Dividing the eagle use season into 2 week periods results in approximately 5 periods. This in turn equates to 6 to 7 prey items per eagle per time period. For example, 600 eagles present in the Basin would need 3,600 to 4,200 prey items in a two week time period. Most of the waterfowl eaten by eagles are sick or dead (Keister et al. 1987) so barring a disease outbreak, if the natural mortality of ducks in winter is 3 to 4 percent, a steady population of 125,000 waterfowl would provide the necessary number of prey from natural mortality alone. Combined with eagles supplementing scavenging with pursuit and capture of healthy birds the 125,000 threshold appears to be adequate

to provide for the number of eagles that are likely (given historical data) to winter in the Lower Klamath NWR in most years.

Information regarding the energetic needs of eagles corroborates the waterfowl threshold number of 125,000. The Service consider this threshold applies when open water for waterfowl is available and bald eagle numbers fall within the previously-documented range. However, years of unusually high numbers of eagles above the documented range and would increase the bald eagle's need above the threshold.

3.4.3. Derived Minimum Water Delivery to Sustain Waterfowl Habitat to Support the Waterfowl Threshold Number of 125,000

Because the proposed action is water delivery, the Service's previous analysis of waterfowl and habitat acres must be translated into water delivered. Using the above analysis, the Service estimates the amount of water necessary to maintain waterfowl habitat during the wintering period sufficient to harbor 125,000 waterfowl would be 32,255 acre-feet of water delivered to the Lower Klamath NWR as described below. This analytical approach is consistent with the Implementation Plan for Recovery of the bald eagle in Washington and Oregon which states " ...maintain winter habitat sufficient to support a population of wintering bald eagles equal to or greater than the current population..." (WDW 1990).

Using the best available information, including the action agencies' data and technical assistance, the Service devised a water and habitat management method to attain a high probability of maintaining habitat for 125,000 waterfowl throughout the winter while using as little water as possible. This analysis step was necessary to determine the water delivery level below which sufficient waterfowl habitat could not be maintained. The water and habitat management method will be called the adverse effects avoidance management (AEAM) and is described in Table 2. The AEAM is based on careful water delivery to manipulate Lower Klamath NWR habitat to maximize its diversity and minimize the amount of area and water used. The AEAM in Table 2 describes the specific Lower Klamath NWR areas that would receive the water, the season of use and rationale for use under the AEAM. Table 3 is based on information from the environmental baseline and compares past data on waterfowl numbers and various habitat regimes to the AEAM. Table 3 information establishes that the AEAM is within Lower Klamath NWR water delivery levels achieved in the past, even during relatively low water, and is possible water delivery for analysis purposes

Table 2. AEAM. Description of specific areas that would need to receive water, timing of water delivery and retention, and supporting rationale.

Habitat	**Acres**	**Water needs** (cfs)	**Rationale**
Seasonally flooded wetland. Units 4B, 4C,9A, 11AN, 12A	2,482	September = 61 October = 61 November = 14 **Total = 8,131 a-f**	Flooding of seasonal marshes attracts and holds preferred waterfowl prey species (mallard, pintail, wigeon) and maintains Lower Klamath NWR as a traditional waterfowl and eagle staging and wintering location.
Permanent wetland Units 2, 8B, 12C	6,053	Apr = 28 May = 41 Jun = 55 Jul = 69 Aug = 60 Sep = 45 Oct = 24 **Total = 17,719 a-f**	Provide feeding and loafing habitat for waterfowl using seasonal wetlands and flooding grain fields. Unit 2 is a primary staging area for waterfowl using KDD lands and LKNWR and is close to the Bear Valley NWR night roost. Unit 8B and 12C are close to the Mt. Dome eagle night roost. These locations are intended to minimize distance eagles travel to forage.
Small grains Units 7B, 12B, 11C	2,431	Dec = 30 Jan = 38 Feb = 36 **Total = 6,405 a-f**	Flooding of small grain fields in winter provides important food and open water to waterfowl when seasonal marshes have frozen. This practice also makes mice available to feeding eagles. Some avian cholera in waterfowl traditionally occurs in flooding grainfields making them attractive to foraging eagles.
All wetland habitats combined	8,535	**Grand total = 32,255 a-f**	

Table 3. Comparison of AEAM to recent past water delivery levels and habitats important to waterfowl and bald eagles on Lower Klamath National Wildlife Refuge in 1992, 1994, and a year of full water delivery (planned for 2001).

Year	Permanent wetland Acres	Seasonal wetland[1] Acres	Acres of Small grains[2]	Total wetland Acres	Acre-feet of Water need/use[3]	Peak fall waterfowl	January waterfowl	January eagles
2001 Habitat Plan[4]	11,163	8,161	4,476	19,324	68,973	up to 1.8 M	up to 340K	up to 958
1992	5,005	6,258	3,986	11,263	43,930	804K	3,750	51
1994	9,104	4,955	3,648	14,059	50,974	607K	166,000	465
Minimum habitat needs	6,094	2,670	2,431	8,535	32,255	300-600K	100-200K	up to 600

[1] Flooded prior to October 31. Other wetlands would flood after this date.
[2] Flooded December, January, and February.
[3] Water need/use May-October for permanent and seasonal wetlands and Dec-Feb. for winter irrigation of grain.
[4] Water management planning assuming full water delivery to Lower Klamath NWR sufficient to meet the refuge's legislated purposes for a full range of endemic species.

As Table 3 indicates, the AEAM would use less water than was used in the years of 1992 and 1994 when water supplies were very limited. The AEAM strategy would avoid adverse effects on wintering bald eagles by providing habitat sufficient for the waterfowl threshold number, if the Service's calculations are correct, and waterfowl populations do not drop due to weather or other conditions. The AEAM habitat configuration would crowd waterfowl into relatively smaller areas, and make them more susceptible to predation by eagles. The Service notes this scenario is very simplified and does not support the habitat requirements that may be necessary to support other fish and wildlife species on the refuge the Service is charged to protect.

3.4.4. Effects on Wintering Bald Eagles when Lower Klamath NWR Water Delivery Does Not Meet AEAM

The proposed action does not state a plan to provide water delivery at any minimum level, and would likely deliver less than the 32,255 acre-feet necessary to maintain the AEAM for the waterfowl threshold of 125,000 in some years. The Service's analysis suggests maintenance of less than 125,000 waterfowl would likely adversely affect bald eagles, and as waterfowl numbers drop, adverse effects on affected individuals would likely increase and the number of eagles adversely affected would also likely increase. Because the action agencies' description of the proposed action lacks such information, the Service cannot be certain of the frequency or pattern of when the proposed operation would result in Lower Klamath NWR water delivery below 32,255 acre. Despite this uncertainty in the frequency and timing of such effects, they are nearly certain to occur in some years, as analyzed below. In addition, below is a description of the nature of the adverse effects likely to occur whenever water deliver deviates from the AEAM.

Under the proposed action water delivery would be reduced or non-existent in drought or low water years, and thus would significantly decrease in the number of waterfowl that winter there as compared to current water delivery. Water levels below the AEAM 32,255 acre feet would be insufficient to maintain a minimum of 125,000 waterfowl on the NWR would adversely affect wintering eagles. Insufficient water levels are most likely to occur during drought and low water years and could coincide with large numbers of eagles being pushed into the Basin by low food levels elsewhere.

As discussed in the environmental baseline section, over the last 9 years Reclamation has halted water supplies to the Lower Klamath NWR four times (not including 2001). The results of those changes to water availability have varied depending on many factors. In 1992 and 1994, even with interrupted delivery, the refuge received more water than the AEAM, as indicated in Table 3. Even delivery of more water than the AEAM total of 32,255 acre-feet delivered in the wrong season may not avoid adverse effects on bald eagles. Under the proposed action, the reasonable and prudent alternative for endangered suckers, and based on past water years, the Service estimates that in 25 to 50 percent of water years the Lower Klamath NWR would not receive enough water to manage habitat to attract the waterfowl threshold number.

Several successive years of drought and low waterfowl numbers could occur under the proposed action on the NWR. Under the proposed action, individual eagles that migrate to winter on the NWR in years of insufficient waterfowl supply would be affected to various degrees. Immature eagles would be affected most severely by the proposed action, and the proposed action likely would increase the small percentage that may die due to starvation on-site, during dispersal to other wintering food sources, or injury sustained during battles over food with other eagles. Adult eagles would likely fare better than young and relatively fewer of them would die from starvation or suffer injury during competitive battles. However, many adult eagles would likely suffer reduced weight gain from lack of food, potentially resulting in reduced productivity at their nesting territories. Some eagles may leave the area attempting to locate a more favorable wintering ground. These eagles would also likely suffer reduced weight gain and lowered reproductive success after arriving late, and likely in poor condition, at a different wintering area. The likely effect of deaths of mainly immature eagles, and temporarily reduced reproductive success would be spread across the Pacific Recovery Area and some areas of Canada because wintering birds originate from inside and outside the Pacific Recovery Area.

Inadequate waterfowl food would likely result in several outcomes over several years because eagles tend to use the same feeding areas from year to year. For example, even years after fall food supplies disappeared in Glacier National Park, eagles identified from patagial tags were seen moving through the area on their way to wintering areas in Idaho, Montana and Utah (McClelland 1994). Glacier National Park was an autumn migratory stop not a winter destination. Similarly, use of wintering areas by eagles also seems to be traditional in that it follows patterns learned in the past (Isaacs et al. 1996). Many studies on repeated wintering use and eagle behavior indicate eagles would continue to migrate to the Klamath Basin and Lower Klamath NWR to winter even if waterfowl are not available as a food source. Eagles that would arrive and finding diminished or non-existent waterfowl concentrations due to the proposed action would likely have to forage a much wider area to locate smaller or short-term food supplies, and some may remain in the area and suffer lowered fitness than if the proposed action were not implemented. Often, immature eagles are greater in number than adults at wintering areas. Because immature bald eagles are

inexperienced and less capable of foraging (Knight and Knight 1983) they would be more likely to suffer stress, lowered fitness and mortality from the proposed action than adult eagles.

The need for eagles to range wider in search of prey during shortages at traditionally steady food supplies was demonstrated by radio telemetry data on wintering bald eagles in Missouri. Foraging eagles were fitted with transmitters and followed during different years. The data showed that when waterfowl concentrations were low, eagles ranged more widely and spent more time searching for prey (Griffin and Baskett 1985). In fact for the year 1976 the average size of a foraging eagle range was 2.6 times greater than 1978, a year when waterfowl were abundant.

In the Basin, eagles may be forced to search for dead ranch animals, road killed mammals and hunter wounded deer and elk. Any of these potential sources of would be less concentrated than waterfowl and more likely to expose the birds to harassment or danger. This is supported by observations in the Basin. The winter of 1992-1993 was a cold winter and in January of 1993 waterfowl numbers on Lower Klamath dropped to 3,750 largely due to ice cover. At this same time 51 eagles were recorded on Lower Klamath. At a small wintering area on the John Day River, bald eagle numbers dropped also (Isaacs et al. 1996). Researchers attributed it to ice cover and snow cover on the landscape all which would have reduced prey availability (Isaacs et al. 1996) motivating eagles to search wider for prey. The same year, Klamath Basin NWR personnel started getting reports of many eagles feeding on roadkills and in areas nearer to humans (J. Hainline and D. Mauser, pers. comm.). These behaviors and movements by stressed eagles increases the risk of death from injury (road kills, power lines, indiscriminate shooting and exposure) and puts at risk the fitness of the eagles returning to other areas to breed. Those observations demonstrated the relationship between foraging patterns in the basin during low prey availability were similar to those recorded elsewhere. The shift in behavior due to scarce or missing food greatly increased the likelihood of starvation and injury.

Another example of a behavior shift occurred along the Colorado River corridor. A study by Riper et al. (1995) collected data on a recent bald eagle wintering population feeding on spawning trout. Observations showed a closely parallel trend between number of spawning trout and numbers of wintering eagles from 1989 to 1994. During 1992-1994 numbers of wintering eagles was low. In 1994, Riper et al. (1995) "received numerous reports from state and federal agency biologists of small eagle concentrations at elk and deer carcasses over the southern Colorado Plateau." Brown (1993) also observed shifts in areas that were foraged even within river habitats. When prey density in the shallow edge of the Colorado River dropped, eagles spent more foraging effort in the deeper parts of the river and had a lower success rate. These studies clearly demonstrate that as prey abundance drops eagles forage more widely and are less successful.

Farther north, in Alaska, where conditions are more difficult large numbers of young birds perish of starvation before reaching adulthood (Sherrod et al. in Stalmaster and Gessaman 1984). This information and data from the telemetry data in Missouri (Griffin and Baskett 1985) suggests that eagles do not readily leave traditional concentrated food sources even when faced with reduced or absent prey. Since availability of prey is correlated closely with eagle numbers it is likely that most food concentration areas are saturated already (Hunt et al. 1992) or are not suitable.

In the Central Valley of California, waterfowl winter in very large numbers and the conditions in that area lead to thousands of ducks dying from cholera. However bald eagles have not used this

large food source to any significant degree. In fact, the presence of more than a few transient eagles in that area is unusual (D. Mauser, pers. comm.). In 2000, the midwinter count showed 28 eagles and that was higher than usual (J. Silveira, pers. comm.). A study from 1985-1987 on eagle interactions with cackling geese in 4 California valleys showed less than 10 eagles in the Sacramento Valley, San Joaquin Valley and Big Valley study areas. By contrast the Klamath Basin study area had between 109 and 965 eagles (McWilliams et al. 1994). Data collected from winter bald eagle counts since 1987 does show consistent presence of eagles in specific areas of Northern California. Some of these areas are Bear Valley, Butte Valley, Cache Creek, Clear Lake, Claire Engle Lake, Eagle Lake, Lake Almanor, Lake Britton, Shasta Lake, and Modoc National Wildlife Refuge. Most of these sites average fewer than 30 eagles, but Eagle Lake, Shasta Lake, Clair Engle have had more than 50 birds. Eagle Lake's bald eagle count has been increasing substantially in the last decade and has averaged 175 birds over the last 4 years. The Klamath Basin over the same period averaged 207. These counts are conducted before the number of eagles reaches its peak in the Basin. In ten of the last 14 years, Klamath Basin has had the highest wintering eagle counts, demonstrating the relative importance of the Klamath Basin. Increasing numbers of wintering bald eagles at many of the California sites may eventually surpass prey available at those sites.

The reason the Central Valley is not used by many eagles is not known. One possible reason is that the Central Valley lacks subtle habitat elements, such as climate that does not support the formation of partial lake ice. We do not know that lake ice is essential, but lake ice does form in Lower Klamath and provides advantages of a feeding platform, concentration of waterfowl into smaller areas, and an edge toward which carcasses drift. Ice also reduces competition from other mammal scavengers. In short, ice provides a unique and shifting habitat that provides food and security. Another possible reason is the lack of coniferous roost trees. While plenty of deciduous roost trees occur in the Central Valley and are used as roosts, conifers are used as roosts in the Klamath Basin, and may be preferred by bald eagles.

3.4.4.5 Summary of Effects

Implementation of the proposed operation is likely to reduce foraging areas used by nesting and wintering bald eagles and would decrease protection and conservation of these areas when compared to past Klamath Project operations. The exact magnitude and extent of these effects cannot be easily calculated, but the general nature of these effects is well understood and supported by the best available scientific information. Especially in low water years, food stress caused by lower waterfowl concentrations is likely to force some bald eagles that have traditionally wintered in the action area to disperse into sub-optimal wintering habitats outside the action area. Some eagles likely will suffer reduced physical condition during the wintering period, some will forage in areas that will result in injury, some will carry a lowered fitness to nesting areas, will exhibit a reduced reproductive capability, and reproduce less successfully than if the proposed action were not implemented. More eagles, predominately immatures, will starve to death than if the proposed project were not implemented. Because wintering eagles come to the Basin from many western states and Canada, the impaired health and loss of individuals from the wintering population will affect birds from a large portion of the eagle's range.

<u>Range-wide Perspective</u>. Maintenance of existing conservation efforts is suggested by the area-specific Recovery Plans for the bald eagle as a conservation need, with particular emphasis on

maintenance of existing adult breeding eagles. Wintering habitat was identified as a particularly important aspect of maintaining adult breeding eagles. The proposed action would not change most existing conservation efforts throughout the range, but would not maintain conservation efforts in the Klamath Basin related to foraging resources for wintering and nesting bald eagles.

Pacific States Recovery Area Perspective. The Pacific States Bald Eagle Recovery Plan identified four recovery criteria, and below each is compared against the effects of the proposed action.

1. The PRA should have a minimum of 800 nesting pairs.

In 1998, there were approximately 1,480 nesting pairs in the Pacific Recovery Area (USDI 1999), including the action area. In addition, a large, but unknown number of non breeding adult and immature eagles occur in the Pacific Recovery Area (PRA) and in the action the area. Currently, the number of nesting pairs in the PRA is almost twice the recovery goal of 800 for the area and is increasing. The proposed action would potentially affect nesting success of the 117 pairs that nest in the Klamath Basin. The effects of the proposed action would likely reduce nesting success of some or all 117 pairs that currently use the Klamath Basin, potentially causing a reduction in total pairs that use the Basin. However, successful nesting is expected to occur in the Klamath Basin if the proposed action were implemented, but reproduction likely would be reduced. Given the large number of nests as compared to the estimate of 800 needed to recover the species, the reduction in nesting success of bald eagles is not likely significant.

2. PRA pairs should produce an annual average of at least one fledged young per pair, with an average success rate per occupied territory not less than 65% over a five year period.

The five year nesting success of bald eagles in the Klamath Recovery Zone is 64% and 61% in Oregon. The proposed action may reduce nesting success on 117 pairs, as indicated above, but the significance of this reduction is not immediately clear. For example, one reason the nesting success is already below the recovery goal may be related to the relatively high dense nesting use, nearly double that anticipated in the nesting pairs recovery goal (1, above). Eagles that nest in close proximity to one another compete for the same resources, and have been observed to injure each other during competitive interactions. The relatively large number of nests in close proximity to one another may preclude achievement of this recovery goal. Recent thinking indicates that achievement of this recovery goal may not be necessary to achieve recovery; as indicated earlier, the longevity of bald eagles makes survival of individual birds potentially more important than maintenance of high reproductive rates. Conversely, failure to achieve this recovery goal may also be an indication of a serious loss of available nesting territories necessary for recovery. However, because the number of nesting pairs is so much greater than the recovery goal, the combination of higher numbers of pairs but lowered per pair nesting success is likely suitable for recovery and the effect of the proposed action on up to 117 pairs is not likely significant, in and of itself.

3. PRA recovery goals must be met in at least 80% of the management zones.

The Klamath Basin contains 1 recovery zone, or roughly 2% of the recovery zones in the PRA. The Klamath Basin Recovery Zone exceeded the goals for nesting pairs, but does not achieve the

nesting success rate of #2, above. The effects of the proposed action on the recovery goals 1 and 2 are discussed above. The effect of the proposed project on the population recovery goals of other recovery zones are related to wintering, and are discussed in wintering, 4, below. Overall, the Pacific Recovery Area has nearly met this goal, with 76% of recovery zones at or exceeding criteria for number of pairs (USDOI, 1999).

4. Wintering populations greater than 100 individuals should be stable or increasing.

This recovery goal applies to all individual wintering areas, including the Klamath Basin wintering areas that would be affected by the proposed action. Under the proposed action, the trend in the predictability, abundance, and availability of waterfowl for wintering eagles cannot be described as stable. The average number of eagles counted in the Klamath Basin in winter counts is approximately 375 but varies widely, up to1,100. The proposed action may adversely affect bald eagles that winter in the Klamath Basin, as described above. The proposed action would adversely affect wintering habitat and individual bald eagles that use the habitat to varying degrees, depending upon many factors. The proposed action would adversely affect more habitat and more eagles than current and recent past operations of the Klamath Project. The Service's analysis shows the Klamath Project can be operated to provide adequate water delivery to the Lower Klamath NWR bald eagle wintering area to maintain waterfowl numbers above the threshold necessary to maintain concentrations of bald eagles as large as any recorded. The proposed action would not continue the operation of the Klamath Project such that large concentrations of bald eagles are likely to winter in the Lower Klamath NWR in the future. Bald eagles that leave the Lower Klamath NWR due to low water, or that stop migrating there after successive years of low water may begin to winter in the lesser-used California wintering areas.

4.0 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. No additional cumulative effects have been identified at this time.

5.0 CONCLUSION

After reviewing the current status of the bald eagle, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that proposed operation of the Reclamation's Klamath Project, is not likely to jeopardize the continued existence of the bald eagle. No critical habitat is designated for the bald eagle and, therefore, none will be affected. The Service reached this conclusion for the following reasons:

The type and intensity of impairment and injury of nesting and wintering eagles likely to result from implementation of the proposed project would be broad. Likely effects would vary by many factors including the age of individual eagles, proficiency of finding food, and habitat conditions in the surrounding area, and their exposure to alternate wintering areas, such as those in California.

Likely effects range from temporary periods of hunger and increased energy expenditure for less concentrated or lower quality food, increased exposure to injury risks at food sources, increased exposure to inclement weather and lowered fat reserves, to the more extreme forms of reduced fitness during breeding initiation, and death through starvation or injury. The number of eagles killed or permanently injured from implementation of the proposed action is likely to be small compared to the total number of wintering eagles in the Klamath Basin, and small compared to the number of eagles impaired or temporarily injured from implementation of the proposed action. The Service expects many eagles temporarily impaired by implementation of the proposed action would recover and then continue to function as part of the recovering population.

The number of affected nesting bald eagles is small. The number of wintering eagles likely to be injured to the degree of being permanently removed from the recovering population would be only a small proportion of the total breeding and non breeding population in the Pacific Recovery Area. Because the nesting population of the Pacific Recovery Area already greatly exceeds the recovery goal, it seems probable that the direct loss of a small number of wintering birds through death or permanently impaired reproductive ability can be compensated for.

The bald eagle has met most numerical population goals in the United States and has a reported total population that exceeded 5,748 pairs in 1998. The recovery of the species has been broad based across most of the eagles range with the population essentially doubling every 7 or 8 years since 1970 (USDI 1999b).

6.0 INCIDENTAL TAKE STATEMENT

Sections 4(d) and 9 of the Act, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or the applicant. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by Reclamation so they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this incidental take statement. If Reclamation (1) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Bureau of Reclamation must report the

progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

6.1 Amount or Extent of Take

Given the historical range of the numbers of eagles that winter on Lower Klamath NWR, the Service anticipates up to 950 eagles could be incidentally taken, mainly through reduced access to food, per year as a result of the proposed action when water delivery from all sources to the Lower Klamath NWR is below 32,255 acre- feet. Most of the eagles taken by the proposed action would not be killed; most would suffer varying degrees of reduced fitness from lack of food, or injury while obtaining food. The Service anticipates incidental take of bald eagles will be difficult to detect and measure accurately for the following reasons:

- the species is wide-ranging;
- the injury to the species may not be readily observable;
- the effects to the species may not manifest themselves until the breeding season ;
- the effects may be masked by fluctuating populations; and
- individuals that die may do so in remote areas and not be found.

Data analysis by the Service shows that maintenance of 125,000 waterfowl in the winter on the Lower Klamath NWR is likely to adequately support the biological needs of the normal range of eagles that winter there. Further study and examination of past trends of water delivery show that 32,255 acre-feet of water can be used to produce the habitat adequate for that minimum number of waterfowl. Take is likely to occur when Reclamation's water delivery combined with other sources does not reach the 32,225 acre feet minimum. Eagles wintering on Lower Klamath NWR during those years that water sources do not meet the 32,255 acre-foot threshold would likely be taken mainly via injury, or a smaller percentage via death. The Service notes that most eagles taken would not face immediate death or life-threatening injury, but would face reduced fitness or reproductive capacity until they recover from lack of food presented by the effects of the proposed action.

The incidental take is expected to be in the form of harm due to a substantial reduction in available prey. A lack of adequate prey would impair feeding behaviors of wintering eagles resulting in reduced productivity, malnourishment, injuries or accidents, and in some cases death of the affected individuals. This take is expected to occur in each and every year that water deliveries from all sources are lower than necessary to support 125,000 waterfowl on the refuge. The maximum amount of take would be equal to the peak number of eagles using the Klamath Basin and winter roosts during that year.

In addition, the Service anticipates take of up to four pair of nesting eagles at Gerber Reservoir when reservoir levels are dropped to a point where significant reduction in prey populations occurs. Take would be in the form of harm through the impairment of reproduction and could occur in successive years of low fish numbers.

The Service acknowledges that Reclamation's implementation of the Reasonable and Prudent Alternative developed to avoid jeopardizing the continued existence of the Lost River and short nose suckers could increase the number of years in which take of bald eagles would occur. That

increase has been considered in the biological opinion and the Service's conclusion that the proposed action will not jeopardize the continued existence of bald eagles or appreciably reduce the likelihood of recovery.

The Service calculated the long-term take from long-term implementation of the proposed action. This incidental take statement, however, applies only for one year, per Reclamation's March 30, 2001 request to limit the duration of the biological opinion to one year. The exemption provided by this incidental take statement will expire on April 2, 2002, unless Reclamation requests formal adoption of this biological opinion for continued operations of the Klamath Project.

6.2 Effect of the Take

In the accompanying biological opinion, the Service determined this level of anticipated take is not likely to result in jeopardy to the bald eagle.

7.0 REASONABLE AND PRUDENT MEASURES

1. Reclamation shall continue to provide water to the Lower Klamath NWR for use for waterfowl production to support wintering populations of eagles, when water is available in excess of that required for ESA needs in Upper Klamath Lake, Tule Lake and the Klamath River.

2. Reclamation shall work cooperatively with the Service and Refuge staff to develop a plan for providing an artificial food source for wintering eagles. This plan would be used to supplement natural food supplies for wintering eagles in years when the water available is not adequate to provide minimum food resources.

3. Reclamation shall educate contractors and lease holders in ways to manage water in the late winter to benefit wintering eagles.

4. Reclamation shall provide the Service with an annual report on the amount of take resulting from the Project.

Reclamation's comments on the March, 2000 draft opinion suggest that RPM 1 and 2 are more than a minor change to the proposed action. However, Reclamation did not provide substantive information to explain how RPM 1,2 or 4 would result in more than a minor change to the proposed action.

For RPM 1, Reclamation's BA indicates that in critically dry years (the driest during1961-1999) Reclamation delivered an average of 493,650 acre feet for crop and NWR use. The biological opinion established 32,255 acre feet, combined from all sources, as necessary to avoid take and adverse effects on bald eagles. Calculation shows 32,255 acre feet is only 6% of the total delivered to all users in the critically dry years of the past. Also, as previously discussed in the biological opinion, 32,255 acre feet is less water than was delivered to the Refuge in any previous year including the critically dry years. Since the RMP requiring delivery of water would only

come after River flows and lake levels are met, and is consistent with actions taken by Reclamation in the past, the RMP is not more than a minor change.

RMP 2 requires an artificial feeding program be developed for implementation in those years that Reclamation cannot provide adequate water to the Refuge to support waterfowl and wintering bald eagles. In 1992 the Service issued a biological opinion on the Klamath Project that included (as an RPM and Term and Condition) artificial feeding at Gerber Reservoir. That RPM required that monitoring during dry year operations was necessary to ".....identify instances where intervention in the form of supplemental feeding of adults or rescue of young may be appropriate; carry out such actions where appropriate to minimize take"(USFWS 1992). In a 1998 amendment to that opinion, which is the biological opinion under which Reclamation is currently operating, the same RPM and Term and condition is reiterated (USFWS 1998). RPM 2 in this biological opinion and incidental take statement is consistent with conditions in place, and that have been in place in previous consultations since 1992. The Service notes that Reclamation made no previous protest that supplemental feeding was more than a minor change. Artificial feeding for wintering eagles would occur in few years and is specifically aimed at reducing the adverse impacts to individual eagles at the point of impact. For these reasons, RPM 2 is not more than a minor change.

8.0 TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Bureau must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

1. When water is available in excess of that required for Upper Klamath Lake, Tule Lake and the Klamath River for other ESA purposes, the Bureau shall provide water to the Lower Klamath NWR for use in the maintenance of wetlands and other habitats and associated waterfowl populations necessary to support wintering bald eagles

    a. Reclamation shall work cooperatively, with the Service and Refuge staff to develop a strategy for providing a consistent source(s) of water to the Lower Klamath NWR for use for waterfowl production to support wintering populations of eagles.

    b. The amount of water delivered to the Refuge, when combined with other water sources should equal a minimum of 32,255 acre-feet and be delivered in a manner that promotes the overwintering of a minimum of 125,000 waterfowl.

    c. Reclamation shall collaborate with Service and Refuge staff to develop a long-term eagle management plan for wintering eagles in the Basin on Refuge and Reclamation lands.

    d. Reclamation shall issue a report in the spring of each year projecting the amount and timing of water deliveries to the Refuge for the upcoming irrigation season so that if the predicted delivery is less than normal, the Refuge can implement any specific habitat management necessary to support wintering bald eagles.

2. Develop an artificial food program for wintering bald eagles for years when the water available from all sources is inadequate to support adequate prey for wintering eagles.

    a. The program shall be developed cooperatively with Service and Refuge staff.

    b. The program shall be used only during years when all water sources are unable to support an adequate prey base for wintering eagles.

    c. The artificial food shall only include dead native waterfowl or fish, not domestic livestock or ungulate carcasses.

    d. The food shall be delivered and presented in a way that mimics natural conditions.

    e. The program shall be operational as soon as possible.

3. Reclamation shall educate contractors and lease holders of ways to manage water management in the late winter can be of beneficial effect to wintering eagles.

    a. Reclamation through its contracts and leases, shall provide information on how late winter agricultural field flooding can be timed in a way to benefit waterfowl and eagles.

4. Reclamation shall provide an annual report on the amount of take resulting from the Project.

    a. The report shall be issued annually to the Service.

    b. The report shall include progress on implementation of these Terms and Conditions, an enumeration or close estimation of incidental take from the previous calendar year, and a report on implementation of any Conservation Recommendations.

9.0 COORDINATION WITH OTHER WILDLIFE LAWS

To the extent that this statement concludes that take of any threatened or endangered species of migratory bird will result from the agency action for which consultation is being made, the Service will not refer the incidental take of any such migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C §§ 703-712), or the Bald Eagle Protection Act of 1940, as amended (U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions (including amount/or number) specified herein.

10.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and

threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service offers the following conservation recommendations:

2. Reclamation should work toward habitat enhancement and winter irrigation of small grains at Tule Lake to return it to its former role as a feeding area for wintering waterfowl and eagles.

3. Reclamation should aggressively implement strategies to improve wetland and agricultural habitat at conditions that will increase the number of overwintering waterfowl on Tule Lake NWR for the benefit of wintering bald eagles.

4. Reclamation should work toward the burial of power lines on the refuge and other areas where infrastructure is powered by overhead power lines.

5. Reclamation should collaborate with Refuge staff to determine the origin and destination of eagles that use the Basin as a wintering area. This collaboration may include wing marking, satellite telemetry, or other systems to determine the origin or destination of wintering eagles.

11.0 REINITIATION NOTICE

This concludes formal consultation on the proposed action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required 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 that was not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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Section III, PART 2

Biological/Conference Opinions Regarding Operation of the Bureau of Reclamation's Klamath Project and its Effects on the Endangered Lost River Sucker, Endangered Shortnose Sucker, and Proposed Critical Habitat for the Suckers

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Abbreviations

ac-ft = acre-feet
AFA = *Aphanizomenon flos-aquae*
BA = biological assessment
BI A= Bureau of Indian Affairs
BO = biological opinion
BRD = Biological Resources Div. of U.S. Geological Survey
C = Celsius
CDFG = California Department of Fish and Game
Chl-a = chlorophyll-a
cm = centimeter
d = day
DO = dissolved oxygen
FL = fork length
ft = feet (Note: for lake levels, elevations are above mean sea level, USBR datum)
h = hour
IT= incidental take
KID = Klamath Irrigation District
KLS = Klamth largescale sucker (*Catostomus snyderi*)
KSS = Klamath smallscale sucker (*Catostomus rimiculus*)
LRS = Lost River sucker (*Deltistes luxatus*)
LVID = Langell Valley Irrigation District
mg/l = milligrams/liter
mi = mile
NCWQCB = North Coast Water Quality Control Board
NMFS = National Marine Fisheries Service
ODEQ = Oregon Department of Water Quality
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University (Department of Fisheries and Wildlife)
ppb = parts per billion
pH = hydrogen ion concentration
pers. comm. = personal communication
rkm = river kilometer
SNS = shortnose sucker (*Chasmistes brevirostris*)
SOD = sediment oxygen demand
TID = Tulelake Irrigation District
UKL = Upper Klamath Lake
ug/l = micrograms/liter (ppb)
unpub. = unpublished
uS/cm = micro-Seimons per centimeter
USBR = U.S. Bureau of Reclamation
Service = U.S. Fish and Wildlife Service

1.0 STATUS OF SPECIES/CRITICAL HABITAT

This section provides biological/ecological information on the current status of the listed species relevant to formulating the BO. Using the best scientific and commercial information available, this section describes past human and natural events that have led to the current conservation status of the species. The information presented here is the basis against which the effects of the action are measured over the life of the action.

This section of the BO was primarily prepared using information from the following sources: 1) Reclamation's February 13, 2001, BA for this consultation (USBR 2001); 2) July 15, 1996, BO for PacifiCorp and New Earth operations, and Reclamation's BA for this consultation (USBR 1996a; Service 1996); 3) December 1, 1994, proposed rule for sucker critical habitat (Service 1994a); 4) August 11, 1994, BO for operation of Clear Lake (Service 1994b); 5) April 1993 final recovery plan for the suckers (Service 1993a); 6) July 22, 1992, BO on long-term operations of the Klamath Project, and Reclamation's February 28, 1992, BA for this consultation (USBR 1992a; Service 1992a); 7) July 18, 1988, final rule listing the suckers as endangered (Service 1988); 8) recovery plans for Lost River and shortnose suckers (Service 1986, 1998d, 1993); 9) communications with field researchers who have conducted, or are currently conducting, research on the listed suckers; 10) communications with Reclamation personnel and applicants; 11) comments on the March 13, 2001 draft BO; and 12) available scientific reports and publications pertinent to this consultation.

The following Klamath Basin species are federally listed as endangered and are known to occur in the action area and may be affected: 1) The shortnose sucker (*Chasmistes brevirostris*), and 2) the Lost River sucker (*Deltistes luxatus*). The bald eagle (*Haliaeetus leucocephalus*), which is federally listed as threatened, may also be affected.

1.1 Status of Species: Lost River and Shortnose Suckers

The Lost River sucker (LRS) (*Deltistes luxatus*) and shortnose sucker (SNS) *(Chasmistes brevirostris*) were federally listed as endangered on July 18, 1988, because they were at risk of extinction owing to significant population declines with continued downward trends, a lack of recent recruitment, range reduction, habitat loss/degradation and fragmentation, potential hybridization, competition and predation by exotic fishes, and other factors (Service 1988). Both species had been placed on the California rare species list in 1972.

These fish were once very abundant and were important seasonal foods of native Americans and white settlers in the upper Klamath River basin (Cope 1879; Gilbert 1898; Howe 1968). Spawning migrations occurred in the spring at a critical time when winter food stores had been exhausted. The Klamath and Modoc Indians dried suckers for later use. It was estimated that the aboriginal harvest at one site on the Lost River may have been 50 tons annually (Stern 1966). Settlers built a cannery on the Lost River and suckers were also processed into oil and salted for shipment. In 1900, the Klamath Republican newspaper reported that "mullet," as suckers were referred to, were so thick in the Lost River that a man with a pitch fork could throw out a wagon

load in an hour. In 1959, suckers were made a game species under Oregon State law; however, the game fishery was terminated in 1987, just prior to federal listing.

LRS and SNS are called "lake suckers" because they primarily occur in lake (lacustrine) habitats. This contrasts with the majority of sucker species which are riverine. Two related lake suckers are also found in lakes in the Basin and Range physiographic province. The cui-ui, *Chasmistes cujus*, is confined to Pyramid Lake, but historically also occurred in Winnemucca Lake, both in the Lahontan Basin in Nevada. The June sucker, *Chasmistes liorus,* is found only in Utah Lake, Utah, Bonneville Basin (Sigler and Sigler 1987). A third species, the Snake River sucker, *Chasmistes muriei*, became extinct in the 20th Century (Miller and Smith 1981). All extant *Chasmistes* species and the LRS are listed as endangered under the ESA, largely due to water diversions and habitat losses resulting from the effects of certain agricultural practices on water quality.

Lake suckers were more widespread, and undoubtedly much more numerous, before the end of the Pleistocene when the Basin and Range became more arid and the vast pluvial lakes found in the northern region largely dried up. The present distribution of lake suckers is confined to remnants of those pluvial lakes where special situations have allowed the lakes to remain fresh. *Chasmistes* is known from the Miocene and was widely distributed in the West from California, Oregon, Utah, and Wyoming, with considerable fossil material coming from Fossil Lake, Oregon, in the Fort Rock basin (Miller and Smith 1981). A number of extinct *Chasmistes* spp. are known only from fossils (see review in Miller and Smith 1981).

LRS and SNS: Taxonomy and Descriptions

The LRS was described as *Chasmistes luxatus* by Cope in 1879, from specimens collected in UKL. Shortly afterward, Eigenmann (1891) described *Catostomus rex,* from the Lost River and Tule Lake. This species has been regarded as a synonym of *D. luxatus*. Seale (1896) created the monotypic genus *Deltistes* based on its unique gill raker morphology. Various authors, including Andreasen, Miller, Miller and Smith, and Bailey, have placed this taxon in either *Deltistes* or *Catostomus,* but currently *Deltistes* is the name accepted by most fish biologists, including the American Fisheries Society, and is the name the Service has adopted.

The SNS was described as *Chasmistes brevirostris* by Cope (1879) based on specimens from UKL. Two additional species, *C. stomias* and *C. copei,* were later described by Gilbert (1898) and Evermann and Meek (1898), respectively from UKL and vicinity. These were synonomized with *C. brevirostris* by Miller and Smith (1981). Fowler (1913) suggested that *C. brevirostris* should be transferred to the genus *Lipomyzon*, but this has not been accepted by later workers.

Adult LRS can reach 39 inches in length (with females being slightly larger than males). Adult SNS are smaller, and are generally less than 20 inches in length. The various Klamath species are best distinguished by multivariate discrimination utilizing lip morphology, vertebral counts, gillraker counts, and head shape (Markle and Simon1993). Cavalluzzi and Markle (OSU) have produced a key based on a suite of characters, including: position of lip relative to maxilla, presence or absence of gap between lower lip lobes, lip fleshiness, lip position, and head and body shape. Nevertheless, field identification is often difficult due to the high degree of

morphological variability expressed by the various species and is frequently dependent on the experience of the observer. Due to the similarity of the SNS and Klamath largescale suckers, and the difficulty of making accurate field identifications, the Service will treat these two species as SNS for the purpose of this consultation.

Genetics and Hybridization

There has been considerable interest in sucker genetics because of its relationship to conservation. Tranah and May (1998, 1999), using molecular genetic techniques ("AFLP-SSCP"), identified taxon-specific markers in LRS, while a single genetic marker was present in SNS. SNS and largescale suckers, although distinct, were found to be genetically very similar. Population-specific markers were also present and are being studied further. Additional genetic studies are also underway at the University of Arizona and Oregon State University (OSU). Wagman et al. found evidence of a naturally occurring lethal homozygous genotype in Klamath basin suckers (Wagman et al. 1999; Wagman and Markle 2000b). The significance of this is unknown but it could affect survival of young suckers.

Hybridization was believed to be widely occurring in Klamath basin suckers and was considered a threat by the Service at time of listing (Service 1988). It was suspected that hybridization was indicative of a limitation of spawning habitat and resultant cross-fertilization of eggs (Williams et al. 1985). Koch and Contreras (1973) noted that suckers in the Lost River system were never taxonomically distinct except for those in Clear Lake. Andreasen (1975) believed that some hybridization had occurred between Lost River and Klamath largescale suckers, and shortnose and Klamath largescale suckers, and had occurred to such an extent in the Lost River that the shortnose was no longer present there as a distinct species. SNS in the Lost River system are atypical and resemble *C. snyderi*, and have adapted to conditions in streams and small reservoirs there. Miller and Smith (1981) also suggested that the SNS from Clear Lake were introgressed with C. Snyderi; however, meristic data indicates these fish are SNS (M. Buettner, USBR, pers. comm. 1999). Ziller (1985), during studies on the sucker population status in the Sprague River reported that 8% of those suckers collected were "hybrids". Bienz and Ziller (1987) later determined that 35% of suckers from the Williamson/Sprague River identified with some SNS characteristics were classified as "hybrids". Miller and Smith (1981) considered that the SNS specimens they examined from UKL did not fit any of the recognized taxa, and could be shortnose-Klamath largescale (KLS) "hybrids." Markle et al. (2000) reported that 6% of the adult suckers collected in the lower Williamson River in 1999 were possible "hybrids". Cunningham and Shivley (2001) reported that 17% of suckers collected in the lower Williamson River in 2000 were potential "hybrids". An even greater percentage (31%, considered to be LRS x KLS "hybrids") was collected in the fish ladder at the Chiloquin Dam (Shivley et al. 2001). These values are considerably higher than the 1% "hybrids" found at shoreline spawning sites along UKL, which are dominated by LRS.

Currently it is uncertain if the observed morphological intermediacy observed in some individual fish is due to a natural tendency within the Klamath suckers for extreme phenotypic plasticity, close genetic relationships, hybridization, or a combination of these factors. Early allozyme studies failed to identify hybrids (Moyle and Berg 1991; Buth and Haglund 1994). More studies

are needed to determine what causes this extreme situation of variable morphology and to identify any risk it may pose to the fish.

In 1997, Reclamation assembled several different laboratories using independent strategies to find genetic markers to resolve questions regarding reproductive isolation, classification, systematic relationships, and extent of hybridization among Klamath Basin suckers. Oregon State University (OSU) has been studying sucker meristic and morphometric parameters and single copy nuclear DNA techniques. Arizona State University (ASU) geneticists are using mitochondrial DNA sequence variation methods and University of California, Davis researchers have evaluated allozyme, amplified fragment length polymorphisms (AFLP) and nuclear microsatellite methods.

Wagman and Markle (2000a) examined 28 randomly chosen loci, sequenced 10,421base pairs, and found no fixed differences in four Klamath Basin sucker species. Some of the loci were much better markers for outgroup species, like the Klamath smallscale suckers from the Rogue River, than for the Klamath Basin suckers and suggested that the technique is useful. The authors concluded that, based on their investigation, the Klamath Basin sucker species are similar genetically. Genetic similarity might be a result of hybridization and that hybridization could be a natural and necessary source of genetic variation.

Tranah and May (1998, 1999) screened 66 allozyme loci and determined that there was a lack of sufficiently diagnostic variation to continue to use this method. Use of AFLP techniques proved to be more diagnostic. A number of taxon specific markers were found for LRS and smallscale suckers including several population specific markers. One marker specific to SNS was detected while no bands specific to largescale suckers were found. Interspecific comparisons demonstrated that shortnose and largescale suckers, although distinct, are genetically very similar. The close genetic relationship of these taxa suggests either "recent" introgressive hybridization or recent speciation between these groups. Here "recent," refers to evolutionary history and could be tens of thousands of years or more. LRS from Clear Lake and UKL are very similar and form a distinct group that is more closely related to the shortnose-largescale cluster than to the smallscale group. The Rogue River and Klamath populations of smallscale form the most distinct group.

Mitochondrial DNA studies produced similar preliminary results, suggesting that all Klamath Basin suckers were similar genetically (Dowling 1999, 2000). He surmised that all species have been influenced by hybridization in the past, with recent isolation obtained by smallscale and LRS. Shortnose and largescale suckers were similar and gene exchange among these forms still occurs. LRS have retained substantial genetic distinctiveness, suggesting continued reproductive isolation.

OSU and ASU combined meristic and morphometric and mitochondrial DNA analyses of Klamath Basin suckers (Markle et al. 2000b). Based on these efforts, four species can be recognized, each with two or more recognizable geographic forms. Rogue and Klamath basin smallscale suckers differ in morphological characters associated with dorsal fin placement and in mtDNA. LRS and SNS from Lost River and Upper Klamath subbasins differed in meristic features. Klamath largescale suckers had morphological and meristic differences between the Upper Williamson, Sprague and Lost River sub-basins and some individuals from the Upper Williamson had a unique mt-DNA haplotype. Hybridization rates may approach 10% for some populations.

Markle et al. (2000b) stated that all of the evidence supports the idea that Klamath Basin suckers are part of a species complex or "syngameon." "Syngameons" are groups of interbreeding species that maintain their ecological, morphological, genetic, and evolutionary integrity in spite of hybridization. Botanists have many examples of syngameons, which have been ecologically and evolutionary distinct for millions of years and hybridizing throughout (Templeton as cited by Markle et al. 2000b). Apparently, the morphological and ecological differences between species must be maintained by selection.

Natural History

Diet

LRS and SNS feed primarily on zooplankton and aquatic insect larvae (Buettner and Scoppettone 1990; Scoppettone et al.1995; Parker et al. 2000). LRS eat benthic chironomids, which are larval midges, while SNS feeds mostly on planktonic zooplankton, namely the cladocerans, *Daphnia* and *Chydorus* spp. Both suckers consume detritus and have long guts characteristic of detritivores (Parker et al. 2000). LRS and SNS appear to feed on the larger size classes of available prey (Parker et al. 2000).

Longevity and Growth Rates

Suckers are aged by counting growth rings in opercules (bones in the gill cover) or otoliths (ear bones). Both sucker species can be long lived, with LRS from UKL documented to reach at least 43 years of age, and SNS from Copco Reservoir reaching 33 years of age (Scoppettone 1988). Bienz and Ziller (1987) aged 10 adult SNS that were found dead in UKL in August 1986. Six fish were 19 years old, the remaining fish were 12, seven, seven and four years old respectively. Scoppettone and Coleman (unpub.) aged 190 LRS found dead in UKL in August 1986. Ninety percent of the fish were greater than19 years of age; no fish were less than 8 years of age.

Simon et al.(2000) emphasize that small changes in mortality and growth rates of larvae and juveniles can, over sufficient time, lead to significant changes in recruitment. Simon et al.(2000) found that growth rates of juveniles was correlated with temperature. Age 0 suckers (those in their first year) have growth rates >0.5 mm/day, with LRS rates being higher than for SNS. Relative to other years, age 0 sucker growth was low in 1995, a year of cool water temperatures (Simon et al 2000).

Reproduction and Spawning

Sexual maturity for LRS begins at about four years of age for males and 7-9 for females (Buettner and Scoppettone 1990; Perkins, Scoppettone; and Buettner, in prep.). Most SNS reach sexual maturity at 6-7 years (Buettner and Scoppettone 1990). Both species are highly fecund with up to 70,000 and 200,000 eggs being produced in one spawning season by each female SNS and LRS, respectively (Perkins et al 2000a). Larger females produce more eggs.

Adult SNS and LRS primarily occupy lake habitats and migrate into tributaries to spawn. Such fish are referred to as "adfluvial." Suckers also spawn in suitable nearshore habitats in UKL and perhaps in other reservoirs, as described below. There may also be resident "fluvial" SNS that both live and spawn in streams in the Lost River sub-basin, at least during years of adequate precipitation.

Timing of Spawning Migrations

The timing of spawning migration is somewhat variable form year to year, and is apparently dependent on age, species, sex, and environmental conditions. Larger suckers and males appear to migrate earlier than smaller ones and females. LRS tend to spawn earlier than SNS (Andreason 1975; Ziller 1985; Perkins et al. 2000a). LRS may aggregate at spawning sites on the eastern shore of UKL as early as February. Temperatures at spring outlets where spawning occurs can be 10E C or more above ambient lake temperatures at that time (Andreasen 1975). Within the Sprague and Williamson River watershed, suckers begin their spawning migration as early as February (Markle 1993), with spawning activity often continuing well into May (Andreasen 1975; Buettner and Scoppettone 1990) or June, depending on flow regimes and temperatures. Spawning migration peaks between mid-April and early May (Andreasen 1975; Markle 1993; Perkins et al. 1997; Markle et al. 2000a; Perkins et al. 2000a). LRS and SNS numbers in the fish ladder at Chiloquin Dam in 1996 peaked in the first half of May (Klamath Tribes 1996); downstream movement peaked in late-May and early-June. In the lower Williamson River, spawning migration begins when temperatures reach about 5E C (Andreasen 1975), but peak migration is associated with water temperatures of 10-15E C (Perkins et al. 1997). LRS spawning in the upper Sprague River may be earlier than that in the lower Sprague or Williamson rivers (Perkins et al. 1997). Golden (1969) suggested that spawning in the Williamson River above the confluence with the Sprague River may be limited by temperature, which remains relatively cool year-round owing to a large spring influence. Spawning runs of adult LRS and SNS up Willow Creek, a tributary of Clear Lake, primarily occurred in February and March, but extended to April and June, respectively (Perkins and Scoppettone1996). LRS spawning migration begins when water temperatures are 4-8E C, while SNS migration starts when temperatures reach 7-10E C.

Some Klamath largescale suckers enter tributaries from the lake in spawning runs, similar to LRS and SNS; however, others are apparently resident in river drainages such as the Sprague (Andreasen 1975; Buettner and Scoppettone 1990).

Upper Klamath Lake Near-Shore Spawning

LRS and SNS spawn at multiple shoreline sites of UKL especially near springs and in areas, mostly along the eastern shore, with a gravel substrate (Buettner and Scopettone 1990). Shoreline- and river-spawning stocks appear to be reproductively isolated, based on tagging returns (Perkins et al. 2000a; Shively et al. 2000a; Hayes and Shively 2001). Historically, suckers spawned at several locations along the western shore of UKL, e.g., Odessa and Harriman springs. Andreasen (1975) reported observing a few suckers spawning in Harriman Spring in 1974. These were apparently among the last suckers to use the spring since there are no later records. Historically, large numbers of suckers spawned at Barkley Spring in Hagelstein Park, along UKL's eastern

shore, but there has not been documented spawning there in the past few decades. Attempts have been made to restore spawning habitat at Barkley Spring by adding gravel but this has been unsuccessful, perhaps because the spring has been so modified and access reduced (M. Buettner, BOR, pers. comm.).

In 1999 and 2000, U.S. Geological Survey (USGS), Biological Resource Division fish biologists sampled known or suspected shoreline spawning sites along the eastern shore (Shively et al.2000; Hayes and Shively 2001). Likely spawning occurred at Sucker, Silver Building, Ouxy, and Boulder springs, and Cinder Flats, and extended from late-February to early June. Most of the spawning occurred at Sucker Springs, Cinder Flats and Silver Building Spring. LRS predominated with many recaptures of previously tagged fish, indicating that there likely is a distinct population of shoreline-spawning suckers. In 2000, 119 of 1,258 LRS collected were found to be previously tagged, and only one of these had been tagged elsewhere. Although few SNS spawn in the shoreline areas of UKL, the numbers of recaptures suggests that they may nonetheless represent a distinct population.

Sucker spawning has been monitored at Sucker Springs during many years between 1987 and 2000 (Perkins et al. 2000a; Shively et al. 2000a; Hayes and Shively 2001). Since 1993, other springs on the east side of the lake, including Silver Building, Barkley, Boulder, and Ouxy, have been monitored occasionally; all but Barkley have been regularly monitored since 1999, as has one non-spring shoreline spawning site, Cinder Flat.

The size of LRS, and annual changes in size distribution, were noticeably different between fish from the springs and the Williamson/Sprague river system from 1987 to 1996. LRS at the springs were consistently larger than those in the rivers (Perkins et al. 2000a). The size distribution of fish at the springs did not change appreciably from 1987 through 1993, except for an influx of smaller males in 1993. However, starting in 1996, and becoming more noticeable in 1997 and 1998, the frequency of females larger than 70 cm FL (fork length) began to decline dramatically (Perkins et al. 2000a; Shively et al. 2000a). Likewise, the frequency of males larger than 60 cm FL was much reduced in 1998-2000 compared to earlier years. Some of the decline in larger fish may have been due to annual fish kills from 1995-1997 that were selective for larger fish (Perkins et al. 2000b). Also gradual attrition of old fish may have occurred. An infusion of smaller males 48-58 cm FL was noted beginning in 1996 and continuing through 2000.

The average size of LRS captured at shoreline spawning areas generally decreased as the spawning season progressed (Perkins et al. 2000a; Shively et al. 2000a). It is possible that individual timing of LRS spawning is affected by size (age). Prior to 1999, the majority of sampling effort occurred before May 1. In 1999 and 2000, suckers were captured from March until early June. Therefore, sampling prior to 1999 may have been biased for larger older fish. Scoppettone et al. (1986) observed that smaller, younger cui-ui at Pyramid Lake spawned near the end of the spawning season.

SNS use of the shoreline springs appears to be much less than by LRS. Perkins et al. (2000a) only captured 67 and 26 SNS from springs in 1993 and 1996 respectively. In 1999 and 2000, 19 and 68 were captured during fairly intensive shoreline sampling (Shively et al. 2000a; R. Shively,

USGS, pers. comm.). Numbers of LRS captured at the shoreline sites in 1993, 1996, 1999, and 2000 were 221, 164, 808, and 1,258 respectively. The larger catches in 1999 and 2000 were related to a substantially increased sampling effort than in 1993 and 1996. The mean size of SNS was 36 cm FL in 1999 and 2000, suggesting the population is now dominated by younger fish.

Historically, sucker spawning occurred at Barkley Springs, Odessa Springs, Harriman Springs, and other lake spring areas (Service 1993a). Reclamation has made infrequent daytime visual observations at these locations during the spring months since 1993. No suckers have been observed. However, the low number of surveys combined with the lack of nighttime observations do not allow these sites to be ruled out as inactive. Visual observations and trammel net surveys have also been made at several shoreline springs on Bare Island, with no spawning suckers observed (USGS 1997). Cinder Flat, a gravelly shoreline site with no discernable spring influence, located north of Ouxy Springs, was a newly monitored spawning location. This site was first reported by fishermen about 1995 and was sampled extensively in 1999 and 2000 by USGS.

From March 9 to June 7, 2000, USGS set trammel nets at 31 potential shoreline spawning sites with suitable substrate (Coen and Shively 2001). Sampling locations were selected based on potential suitability of shoreline substrate for sucker spawning. Most sites were sampled 5-10 times over the course of the field season. Two-hundred-sixty-eight suckers were captured with the majority of fish being captured in the Howard Bay or Modoc Point sites. Netting data did not indicate the presence of any spawning.

Other Upper Klamath Lake Area Spawning Locations

Reclamation monitored sucker spawning migrations from Agency Lake into the Wood River in 1996. Trammel nets were set overnight in Agency Lake near the Wood River mouth at 1-2 week intervals from March 1 to May 14. Twenty-seven SNS,11 males and 16 females, and one female LRS were captured. On May 17, a boat electrofishing survey was conducted in the lower two miles of river. Eleven male SNS were captured in scattered locations.

In spring 1999, USGS infrequently monitored fish in Agency Lake near the mouth of the Wood River over nine days using trammel nets (R. Shively, USGS, pers. comm.). Forty-six suckers were captured including 32 SNS, 2 LRS and 12 suckers showing intermediate characters between SNS and Klamath largescale. One SNS tagged in 1996 at the mouth of the Wood River was recaptured as well as three Klamath largescale suckers tagged at the Sprague River Dam (R. Shively, USGS, pers. comm.). In 2000, nine suckers were collected in 10 sampling efforts, including six SNS, one LRS , one Klamath largescale and one apparent “hybrid”. In 1999, trammel nets were fished overnight (8 hour sets) while in 2000, nets were fished during the evening for 2-4 hours. Further evidence that some spawning is occurring in the Wood River system is also indicated by the presence of larvae collected in downstream drift samples and dip nets (Markle and Simon 1993; Simon and Markle 1997).

Historically, sucker spawning occurred in other UKL tributaries including Crooked Creek, Fort Creek, Sevenmile Creek, Fourmile Creek, Odessa Creek, and Crystal Creek (Stine 1982). Although no rigorous spawning run surveys have been conducted in these locations, infrequent

visual, electrofishing, trap and trammel net surveys have been conducted by Reclamation, USGS, Klamath Tribes, ODFW, Cell Tech, and OSU over the last decade. Mike Dickenson (ODFW fish hatchery) apparently observed spawning runs of suckers several times in Crooked Creek, as late as 1987 (Roger Smith, ODFW pers. comm. 2001). The current status of the runs is unknown. There is no documented evidence of current sucker spawning runs in the other UKL tributaries.

Spawning Habitat Characteristics

LRS and SNS spawn in areas with gravel substrate where eggs are broadcast or slightly buried. Spawning areas in Willow Creek, a tributary of Clear Lake, were studied by Perkins and Scoppettone (1996). LRS spawning sites were 3.7 to 5.5 km upstream from Clear Lake and had the following characteristics: water depth = 0.3-1.3 m, velocity = 0.01-0.8 m/s, substrate = gravel with 66-88% particles >1.25 cm diameter. SNS traveled farther upstream than LRS, going 4.4 to 47 km. SNS spawning sites were similar to LRS but with somewhat higher currents (0.7-1.2 m/s) and greater percentage of gravel (82-91% particles >1.25 cm) (Buettner and Scoppettone 1991). In gravel substrates, eggs are deposited in the top several centimeters, and in cobble between the spaces. However, eggs may be carried downstream where fine sediments have filled inter-cobble spaces (Perkins et al. 2000a). Bienz and Ziller (1987) noted that in the lower Williamson/Sprague rivers SNS were mainly spawning in the downstream areas of pools and riffles at river mile 6 to 10.5, in gravel substrates. Egg predation by predators such as flatworms and fish may be significant (Klamath Tribes 1995).

Larval Biology

Data from studies done at the Klamath Tribe's Braymill Hatchery indicate that LRS incubated at a mean temperature of 14.4E C require an average of 136 thermal units (TU), or nine days to hatch. A "TU" is equal to temperature x days. Swim-up required 278 TU, or 19 days. SNS incubated at 15.3E C required 89 TU or six days for hatching and 250 TU or 16 days for swim-up (Dunsmoor, cited in Perkins and Scoppettone 1996). Therefore, after an approximate 2-3 week incubation and hatching period, larval suckers move out of spawning substrates.

Larvae of adfluvial sucker stocks that spawn in tributaries may spend relatively little time upriver before drifting downstream to the lakes (Buettner and Scoppettone 1990; Cooperman and Markle 2000). In the Williamson River, larval sucker out-migration from spawning sites can begin in May and is generally completed by the end of July. In Willow Creek, emigration of LRS larvae begins around April 1 and lasts until about mid-May (Perkins and Scoppettone 1996). Some SNS emigrate to Clear Lake as juveniles. Very little is known about the early life history of stream-resident suckers.

In 1998 and 1999, OSU biologists studied larval sucker biology in the area of the lower Williamson River and adjacent UKL (Cooperman 1999; Cooperman and Markle 2000; Markle et al. 2000a). Larvae first appeared in the lower river when water temperatures reached 11E C. There were two peaks in abundance, one in late-May and another in mid-June; low but steady production levels extended into early July. Simon et al. (2000) found that median egg hatch dates

for juvenile suckers collected in September was early June, meaning that about 50% of the juveniles came from the relatively small fraction of larvae detected after June 15th.

Bienz and Ziller (1987) reported that sucker larvae in the lower Williamson River were not seen until mid-May in 1983 and 1984. They found no larvae upstream on the Williamson above the confluence with the Sprague River. Peak larval emigration was the first week of July.

At the Link River, larval suckers have been collected as early as April 28th and as late as July 18th (Gutermuth et al. 1999). Collection of some early-stage larvae at the Link River suggests that some spawning occurs nearby at undetected sites or that wind-driven currents rapidly transport larvae down the lake and into the Link River.

OSU biologists also found that sucker larvae were present in drift net samples in the lower Williamson River only between 2100 and 0500 hrs and peaked at 0300 hrs, suggesting that drift is confined to a brief 4-hr period at night; however, alternate dispersal mechanisms are possible (Cooperman and Markle 2000). Perkins and Scoppettone (1996) found in Willow Creek that larvae emigrated in some numbers throughout the night but peaked near midnight. Larvae caught in the Williamson River were primarily preflexion (>93%), those in the lake were primarily postflexion (>94%), and flexion stage larvae were about equally abundant. This suggests that larvae quickly leave the river at or near flexion, possibly in as little as a day or two (Cooperman and Markle 2000). Lake larvae had fuller guts than those from the river indicting that food may be more abundant in the lake than in the river. During the daytime, 90% of the larvae were collected in submerged and emergent vegetation. There is some evidence that larval drift may vary with lunar phases (Markle and Simon 1993; Guthermuth 1998).

OSU systematically monitored larval sucker distribution and relative abundance in UKL from 1995-1999 using larval trawl methods (Simon et al. 2000a). Larval suckers were first captured in late April during most years, peak catches occurred in June, and densities dropped to very low levels by late July.

Sucker larvae have been observed in UKL at Sucker Springs as early as April 1 (M. Buettner, USBR, pers. comm.). Simon et al. (1996) observed substantial numbers of larvae on April 4, 1995, during shoreline searches. Essentially all sucker larvae have transformed to juveniles by the end of July (Simon et al. 2000a).

Larval suckers were distributed throughout Upper Klamath and Agency Lakes from 1995-1999 (Simon et al. 2000a). Catch rates were usually highest at the mouth of the Williamson River or Goose Bay. They were also relatively high near Hagelstein Park in most years. Other sites that occasionally had high numbers include Howard Bay (1996), Ball Bay (1999) and Stone House (1999). Very low catch rates were experienced in Agency Lake from 1995-1999.

Cooperman and Markle (2000) documented substantial numbers of sucker larvae in the area west of the Williamson River mouth. It was previously assumed that few larvae occurred in this area because the Williamson River typically flows east towards Goose Bay. Pop net catches were several times higher for this site than Goose Bay in June 1998. However, later in the season the

Goose Bay area had larger numbers of advanced larvae and juveniles.

Larval fish need to begin feeding before they exhaust their yolk. It has been shown for other species that larval survival, and subsequent year class strength, can be determined by the availability of suitable food during this critical period (Crecco et al. 1983 as cited by Klamath Tribes 1996). Yolk reserves are gone or nearly so by the time the LRS and SNS become flexion mesolarvae. Gut fullness was evaluated on sucker larvae to determine whether they were finding adequate food in the lower Williamson River before entering the lake. In 1989, frequency of full guts was substantially higher in mid-June than mid-May at river kilometer (rkm) 0.1 (Klamath Tribes 1996). Twenty-five percent had empty guts in May while almost none were empty in mid-June. However, in 1995, 76% and 88% of larval suckers collected at rkm 0.7 had empty guts on June 8 and June 15-16 respectively (Klamath Tribes unpub. data).

In 1998, larvae from drift samples in the river seldom had food in the gut, particularly larvae from Modoc Point bridge (Cooperman and Markle 2000). At the lower Williamson River station only 3% had food during May 25-29 compared to 16% during June 15-19, and gut fullness was mostly rated low for fish with food. Most of the larvae captured from daytime pop netting in the Williamson River had empty or low gut fullness indices compared to mostly medium to high gut fullness in lake-captured fish (Cooperman and Markle 2000). Flexion larvae across river and lake zones show a dramatic difference in gut fullness, with the lake-caught larvae much more likely to have food in the gut.

It is suspected that larval suckers subsist mainly on zooplankton, and that larval survival is likely greatly influenced by the degree of coincidence between zooplankton bloom formation and larval entry into nursery areas (Klamath Tribes 1996). High densities of larval suckers may not be able to rear in the lower Williamson River until food production increases, which may explain why postflexion mesolarvae were virtually absent at rkm 0.1 in May, but were present in June of 1989. In 1995, post-flexion mesolarvae and metalarvae were absent from June samples but present in July (Klamath Tribes, unpub. data). Littoral macrophytes may support a more diverse assemblage of small-bodied zooplankters, those that would be useable as food for larval suckers, than open water areas (Wetzel 1983 as cited by Klamath Tribes 1996). This may be one reason for the disproportionate use of the emergent vegetation zone by sucker larvae.

The Klamath Tribes conducted a study in 1999 to assess the effects of starvation on larval sucker growth and survival (Klamath Tribes, unpub. data). The preliminary results show that a 3-day delay in the onset of feeding results in a statistically significant decrease in both burst swimming speed and in body depth. After six days, burst speed was almost half of that of fed larvae and by nine days, a broad array of starvation effects were evident including: body depth and length were reduced, eye diameter smaller, fewer developing fin rays, and burst speed continued to decline. Thus, it is clear that sucker larvae deprived of food begin showing adverse effects after 3-6 days that would make them less able to feed and avoid predators and, as a result, survivorship is likely to be reduced.

Researchers have consistently observed sucker larvae with empty guts in the lower Williamson River(Cooperman and Markle 2000; L. Dunsmoor, Klamath Tribes, pers. comm.). If early feeding

minimizes starvation and reduces vulnerability to predation, larval sucker survivorship would be improved by facilitating transport of larvae through the Williamson River and into UKL. Restoration of the emergent wetland/riparian habitat in the lower Williamson River area may also support greater food resources for sucker larvae. Efforts are currently underway by The Nature Conservancy and other partners to restore the historic form and function of the lower Williamson River Delta.

Numbers of emigrating sucker larvae at Clear Lake were estimated by Perkins and Scoppettone (1996) for 1993 -1994. Numbers of LRS larvae ranged from about 0.5 to 1 million, while SNS larvae ranged from 0.01 to 12 million. In 1995 total emigrating sucker larvae numbered about 2.5 million. Estimated survival from egg to larvae ranged from 1 to 10% for both SNS and LRS.

Sucker Larval Emigration - Williamson River

Intensive larval sucker emigration studies were conducted during 1987, 1988, and 1989 in the lower Williamson River (Buettner and Scoppettone 1990; Klamath Tribes 1996). Estimated total numbers of emigrating sucker larvae at rkm 9.8 were 14, 35, and 73 million for 1987, 1988, and 1989 respectively. In 1989, an additional estimate of the number of emigrating larvae entering UKL was made. Only 4.9 million were estimated at rkm 0.1 from May 1-June 28.

Timing of larval emigration was assessed during four years using drift nets (1987 and 1988 - Buettner and Scoppettone 1990; 1989 - Klamath Tribes 1996; and 1998 - Markle et al. 2000a). Date of first sucker larvae capture for all years was during the first week of May. However, during 1989 substantial numbers of suckers were captured on the first sample day. Peak emigration in the lower Williamson River was as early as mid-May (1987) to as late as mid-June (1998). Substantial numbers of larvae were captured from mid-May to mid-June during all four years. Larval drift was very low by the sampling ending dates (that ranged from June 28 to July 15).

In 1998, OSU monitored larval emigration at the Modoc Point Road bridge on the lower Williamson River (rkm 8). Larval drift sampling began on May 5 and larval suckers were first captured on May 17. However, sucker larvae were first observed in the lower Williamson on

May 5, 1998 (Cooperman and Markle 2000). The last larval sucker captured in the drift net was July 15. Two peaks in larval abundance were documented, at the end of May and middle of June

(Markle et al. 2000a). This compares to peak emigration in 1987-1989 ranging from early May to mid-June (Buettner and Scoppettone 1990; Klamath Tribes 1996).

In 1998, larval sucker movement through the lower Williamson River, as measured by density of larval suckers in drift samples, was largely restricted to 2100-0500 hr with a peak about 0300 hr (Cooperman and Markle 2000). This corresponds closely with diel sampling by Buettner and Scoppettone (1990). Larvae appear to move to the river margins during the day (Klamath Tribes 1996).

All three developmental stages of sucker larvae (protolarvae, mesolarvae, and metalarvae; Snyder and Muth 1988 as cited by the Klamath Tribes 1996) were observed in the Williamson River in 1989 (Klamath Tribes 1996). Each developmental stage lasts about 2-4 weeks. Sucker larvae from mid-May at rkm 9.8 were about 63% protolarvae and 37% flexion mesolarvae while in mid-June protolarvae and flexion mesolarvae were 25% and 75% respectively. Most of the larvae entering the lake in 1989 were flexion mesolarvae (early development stage of mesolarvae), while a small proportion of the emigrating larvae had taken up residence near the river mouth and had developed into postflexion mesolarvae (late development stage of mesolarvae) by mid-June. On June 8 and June 15-16 1995, mostly flexion mesolarvae (11-13mm TL) were collected from pop net samples at rkm 0.7 on the Williamson River. On July 21, approximately 20%, 50%, and 30% were flexion mesolarvae, postflexion mesolarvae, and metalarvae, respectively.

In 1998, 83% of the larvae captured in drift net samples at Modoc Point Road bridge were protolarvae and 17% flexion mesolarvae (Cooperman and Markle 2000). In the lower Williamson River near the mouth 49% were protolarvae and 51% flexion mesolarvae. No post-flexion mesolarvae or metalarvae were collected in drift net samples at the Modoc Point Bridge. Very few were captured in pop net sampling near the mouth.

The Klamath Tribes monitored wind direction and strength in 1989, and found that wind influenced the cross sectional distribution of larvae at the water's surface near the mouth of the Williamson River (Klamath Tribes 1996). On nights when the wind was blowing parallel to the channel, larvae were symmetrically distributed across the channel with the most in the middle and the fewest on the edges. However, when the wind was strong and blowing to the east, perpendicular to the channel, larval distributions were strongly skewed to the eastern channel and shoreline. It is likely, therefore, that wind influences larvae movements and distribution in UKL.

Larval Rearing Habitat in Upper Klamath Lake

Larval habitat in UKL is generally nearshore in water less than 50 cm deep and often associated with aquatic vegetation or some form of structure such as logs or large rocks (Buettner and Scoppettone 1990; Markle and Simon 1994; Klamath Tribes 1995, 1996; Cooperman and Markle 2000). Larvae may be present in schools, especially during the day. In UKL, larvae appear to be concentrated near the mouth of the Williamson River, in Goose Bay, and may also be common in the lower Wood River. These sites are near known spawning areas. Dunsmoor found larval densities as high as 16 larvae/square meter in Goose Bay emergent vegetation (Klamath Tribes 1995).

In 1998, OSU documented that sucker larvae in pop net samples were much more abundant in emergent and submergent macrophytes than in woody vegetation such as willows, and unvegetated areas (Cooperman and Markle 2000). Woody vegetation and unvegetated sites had similar densities. Also, there was no significant difference in numbers of suckers caught in *Sparganium* (bur-reed) and *Scirpus* (bulrush) vegetation types.

Dunsmoor et al. (2000) quantified potential larval habitat adjacent to the Williamson River mouth. It is believed that larvae emigrating from the Williamson River move east and then south along the

shoreline. Because of the large numbers of spawning adult suckers in the Williamson River, the area around the river mouth is believed to be crucial nursery habitat for sucker larvae. As discussed above, aquatic macrophytes may provide a crucial refuge and feeding area for larvae. The structural complexity provided by the vegetation may provide protection from predators, waves, and currents, and may have an increased diversity of zooplankton prey (Dunsmoor 1993; Klamath Tribes 1995). Channelization and diking in the lower Williamson River straightened the channel, eliminating natural meanders and associated wetlands that would be more productive of larval sucker food available while in transit to the lake. Combined with channel deepening and reduced flow velocities, first-feeding larvae may be deprived of a critical food supply as evidenced by the frequency of empty guts that has been observed.

Sucker predation by fathead minnows (*Pimephales promelas*) in the laboratory was greatest at shallow water depths (1 ft) when larvae lacked cover (Dunsmoor 1993; Klamath Tribes 1995). Diurnal predation by a variety of visual predators likely explains why larvae drift in the river at night and are found in aquatic vegetation in UKL during the day. Historically the margins of UKL were much more extensively vegetated but alterations resulting from diking and water level management have reduced vegetated acreage significantly (about 40,000 ac). Based on larval needs for emergent vegetation for cover, Klamath Tribes (1995) recommended that water level elevations at Goose Bay, east of the Williamson River mouth, reach 4142.6 ft on June 1 and 4141.6 ft on July 15, inundating 70% and 28% of emergent habitat, respectively. A similar conclusion was reached in data analyses by Reiser et al. (2001).

Dunsmoor et al. (2000) found that three emergent plant species dominated near the Williamson River mouth: hardstem bulrush or tule (*Scirpus acutus*), knotweed (*Polygonum coccineum*), and river burr reed (*Sparganium eurycarpum*). A strong positive relationship was found between the width of the vegetation zone and the shore cross-sectional area; thus more vegetation was present in areas where more suitable cross-sectional habitat was present. The vegetation was limited by steep slopes and greater depths. Also, the amount of wave energy reaching the shoreline was determined to limit emergent vegetation, especially affecting the distribution of the river burr reed. Of special concern was the observation that extensive areas of shoreline were devoid of emergent vegetation. One critical shoreline is the area east of the Williamson River mouth. Here vegetation was sparse and consisted mostly of knotweed. The study concluded that essential "stepping stones" of existing emergent vegetation be maintained to link the Williamson River mouth with more extensive vegetated shorelines east of Goose Bay.

The importance of bottom substrate for sucker larvae is unknown. Most sites where sucker larvae are found have sand or gravel/cobble substrates. However, substrate along the Tulana shoreline west of the Williamson River where high densities of larvae have been found is mostly peat. Since larval suckers are mostly distributed in the upper part of the water column (Buettner and Scoppettone 1990) substrate may not be a critical habitat parameter.

Water quality associated with larval sucker distributions were monitored in 1996 by OSU during larval fish trawling. Similar to 1995, larval suckers were found in pH ranging from 7 to 10.31 (OSU, unpub. data).

Larval suckers were captured at DO concentrations ranging from 4.5-12.5 mg/l with most occurring at sites with DOs from 5.5-10.5 mg/l (OSU, unpub. data). These results are similar to those documented in 1995 (USBR 1996a). No sucker larvae were sampled at the few sample sites where DOs were 3.5 mg/l. With this exception, the distribution of DO values where fish were found paralleled the DO values at all sampling sites.

Studies on larval entrainment at A-canal showed that large numbers of larvae are also present at the lower end of the lake, as mentioned above (Gutermuth et al. 1998, 1999). It seems likely that these larvae are the result of water movement from known spawning sites, e.g., in the Williamson River or along the UKL eastern shore.

Some information of larval sucker habitat was obtained from several of the upper Klamath River reservoirs by Desjardins and Markle (2000). They found that at Copco Reservoir, larvae were found predominately at non-vegetated sites, even though vegetated sites made up most of the sampling sites.

Larval sucker ecology in Clear Lake is unstudied. It is known that emergent vegetation is nearly nonexistent at the present time. Cover is likely provided by high turbidity and larvae may utilize shallow areas where larger fish predators may be scarce.

Juvenile Habitat

Juvenile sucker (suckers of 2.5-10 cm total length) habitat is generally in nearshore areas less than 1.3 m in depth. Markle and Simon 1993 and Simon et al. 2000b found age 0 juveniles in water mostly less than 50 cm deep, over rocky substrates including rock, gravel, and over gravel and sand mix; juveniles avoided pure sand and softer mud or organic substrates. From 1995-1999, age 0 sampling was based on random monitoring of specific habitat types to provide habitat-specific densities. Highest age 0 sucker densities were found over small mix and gravels and lowest densities were found over fines, sand, and boulders (Simon et al. 2000a). The low catches over boulder substrates may be associated with poor sampling efficiency using cast nets. Diverse substrate types are found mostly in the shoreline areas (<10 m from high-water mark). Fine particle substrates ("muck") occupy the vast majority of the offshore areas. Changes in shoreline substrate corresponding to changes in lake level have not been quantified. Vincent (1968) found that juvenile suckers were only abundant over rocky substrates.

The use of difficult-to-sample vegetated habitats by juveniles is not well understood. Juvenile sucker monitoring by OSU focused on mostly unvegetated locations because of sampling difficulties associated with vegetated areas. However, the Klamath Tribes have observed age 0 juvenile suckers in emergent vegetation along the lower Williamson River and Goose Bay (L. Dunsmoor, Klamath Tribes, pers. comm.), and limited sampling by Reiser et al. (2001) found juvenile LRS in vegetated areas, with about 75% (31 fish) of the juvenile suckers they caught coming from a single site at the outlet of Short Creek on the west side of the lake and an additional 20% (8) from the east side of Agency Straits. USGS conducted trap net surveys near Goose Bay in emergent vegetation and adjacent unvegetated areas during summer 2000. Catch rates were generally higher in the vegetated versus unvegetated sites until early August, when catches were

higher in unvegetated areas; although vegetated habitat availability was limited as water level dropped (R. Shively, USGS pers. comm.). No information is available on distribution of juvenile suckers in extensive stands of emergent vegetation at Hanks Marsh and Upper Klamath Marsh. However, OSU captured very few juvenile suckers adjacent to shoreline marsh habitats on the northern margin of UKL, and along the marsh at Squaw Point, Shoalwater Bay, and Hanks Marsh (Simon et al. 2000b).

Markle and Simon (1994) did some juvenile sucker sampling in Gerber Reservoir. Large numbers were collected in June, suggesting spawning occurs earlier there than in UKL. Markle and Simon suggested that owing to better transparency of Gerber Reservoir water, juvenile suckers may move into deeper water before those in UKL.

Water quality associated with age 0 suckers has been monitored annually since 1994 (Simon et al. 1995, 1996; OSU, unpub. data). Distribution of dissolved oxygen (DO) and pH for all samples and those samples containing suckers from beach seine, cast net and otter trawls have been generally similar, indicating no obvious preference or avoidance of certain water quality conditions.

Adult Habitat

Whereas larvae and juvenile sucker primarily use shallow shoreline habitats, adult suckers are mainly found at deeper depths. Radio-telemetry studies conducted in UKL by Reclamation showed that adult LRS and SNS primarily use water depths of 6-9 ft and infrequently were found at depths of <4 ft (Peck 2000). Reclamation determined that median depths for adult suckers ranged from 5.6 to 9.2 ft during studies extending from 1993 to 1998 (Peck 2000). The lowest median depth of 5.6 ft occurred in 1994 which is the only drought year represented during the study. The lower limit for the 50 percentile value ranged from 4.2 to 6.8 ft, with values for all years being above 5.8 ft except for 1994. These conclusions were supported by additional analysis by Reiser et al. (2001).

There are observations of suckers spawning in shallower depths during the night when cover is provided by darkness. Suckers apparently avoid clear water in UKL except when showing ill effects of poor water quality (M. Buettner, USBR, pers. comm.). These observations suggest that suckers are strongly oriented to cover, primarily depth and turbidity. As will be discussed later in detail, the need to seek adequate depth in UKL may make suckers more vulnerable to the adverse effects of poor water quality because they appear to avoid inflow areas where the water quality is high but there is a lack of cover owing to shallow depths and clarity and appear to remain offshore where water depths are greater but water quality is frequently more adverse.

LRS should be considered an obligate lacustrine fish, as no known population exists in rivers. SNS, on the other hand are present, throughout their life cycle in some riverine habitats, e.g., Lost River, Miller Creek, Willow Creek, and other tributaries of Clear lake and Gerber Reservoir, and therefore SNS should be considered a lacustrine/riverine facultative species. It is not known what SNS feed on in riverine habitats but it seems unlikely that zooplankton is sufficiently abundant in

riverine situations to support SNS.

Perkins and Scoppettone (1996) found adult SNS in Willow Creek resting in the bottom of pools and used undercut banks, overhanging shrubs, and algae as cover.

Historic and Current Sucker Distributions

SNS and LRS were undoubtedly present in Lake Modoc, the Pleistocene lake that inundated all of the upper Klamath Basin from Wood River to Tule Lake below 4240 ft elevation (Dicken 1980). The lake outlet near Keno was at a higher elevation, thus blocking flow below the 4240 ft. elevation. Lake Modoc had several interconnecting arms and was approximately 1,000 square miles in area and 75 miles in length. The lake begun to dry up at the end of the Pleistocene about 10,000 to 12,000 years ago. UKL, Agency Lake, Tule Lake, Swan Lake, and Lower Klamath Lake are the major remaining parts of Lake Modoc.

During historic times SNS and LRS were abundant and widespread in UKL and its lower tributaries, probably including the Lost River system, Clear Lake, Tule Lake and Lower Klamath Lake (Cope 1879; Gilbert 1898; Service 1993a). The Klamath largescale sucker was also widespread in the Upper Klamath Basin, and probably occurred in the Lost River system as well (Andreasen 1975; Buettner and Scoppettone 1990).

LRS historically occurred in the UKL, its tributaries, including the Williamson, Sprague, and Wood rivers; Crooked, Crystal, Sevenmile, and Odessa creeks, and Fourmile Creek and Slough (Stine 1982); and the Lost River system, including Tule Lake, Lower Klamath Lake, and Sheepy Lake (Andreasen 1975; Moyle 1976; Williams et al. 1985).

The distribution of the SNS is less well understood because of its similarity to the Klamath largescale sucker, especially juveniles. SNS historically occurred in UKL and its tributaries (Andreasen 1975; Miller and Smith 1981; Williams et al. 1985); although Moyle (1976) also includes Lake of the Woods and the Lost River system (Sonnevil 1972; Buettner and Scoppettone 1991; Scoppettone and Vinyard 1991; Scoppettone and Buettner 1995; Perkins and Scoppettone 1996). Andreasen (1975) believed that the Lake of the Woods sucker was a distinct species, *Chasmistes stomias,* which became extinct in 1952 owing to fish control operations.

Lost River Sub-Basin: Clear Lake

The Lost River sub-basin, about 2,000 sq. mi. in size, contains major sucker populations in Clear Lake and Gerber reservoirs. Smaller numbers of suckers occur in the Lost River, Miller Creek, and Tule Lake sumps. Most of these are SNS; however, a significant population of LRS is present in Clear Lake.

Clear Lake: Reservoir History

Clear Lake Dam was constructed in 1910 to increase the storage capacity of the pre-existing lake, and to control releases of water for irrigation and flood control. It was also designed to increase

evaporation rates by creating a large surface area with shallow depths in order to reduce downstream flows to reclaimed wetlands near Tule Lake, thus it is not an efficient water storage facility. Seepage losses are also high. Annual evaporation and seepage losses account for over half of the average inflow of water, 128,120 ac-ft, at higher elevations. At maximum storage capacity of 4,543 ft above mean sea level, the reservoir has a surface area of 25,760 acres and a maximum depth of about 30 ft. However, Clear Lake elevations have only surpassed 4,540 ft in four years since 1910 and have never reached maximum storage (Service 1992a); recently, Reclamation has had to control lake levels because of dam safety issues. Approximately 8,000 acres of irrigated lands in Langell Valley depend on water from Clear Lake. These irrigation projects operated by Langell Valley and Horsefly irrigation districts divert approximately 36,000 ac-ft of water each year from Clear Lake (Service 1994b). Most of the Clear Lake watershed is within the Modoc National Forest and very little irrigation occurs in the watershed above the lake; however, the watershed is modified by numerous stock ponds designed to hold water into the summer. Clear Lake and the land immediately around its perimeter comprise Clear Lake National Wildlife Refuge.

Since construction, Clear Lake has been lower than the October 1992 elevation in only 4 years, all during the prolonged drought of the 1930s. In 1934, the water surface elevation was the lowest on record, reaching 4,514.0 ft. Contour maps provided by Reclamation indicate the lowest lake bed elevation is 4513.0 ft. Pre-impoundment elevation records for Clear Lake only exist for a few years (1904-1910), but 4,522.0 ft is the lowest elevation recorded for the natural lake. Inflow to Clear Lake averages 128,120 acre-ft but has varied from 18,380 acre-ft in 1933-1934 to 368,550 acre-ft in 1955-56 (Service 1994b).

Prolonged droughts have frequently affected the Clear Lake watershed. The most extended drought occurred in the 1922-1937 period, when only one year of above-average inflow occurred in 15 years. In the drought of 1987-1992, inflow was above average in only one of six years. Estimated inflows were only 51,310 acre-ft during the 1990-1991 water year and 23,350 acre-ft in the-1991-1992 water year (Service 1994b). Up to 1993, the water surface elevation in Clear Lake at the end of October had steadily declined from 4,531.8 ft in 1989 to 4,526.8 ft in 1990, 4,522. 5 ft in 1991, and 4,519.2 ft in October 1992 as a result of a drought and irrigation water deliveries (USBR, unpub. data). The east lobe of Clear Lake is dry at 4,520 ft, except for a small pool of water near the dam. The 1992 water year inflow to Clear Lake was the third lowest on record (Service 1994b). If the 1993 inflow was similar to that of 1992, Reclamation had predicted that the west lobe of Clear Lake also would be dry, regardless of whether or not water was released for irrigation. Fortunately, the winter of 1992-1993 brought near record rainfall, instead of continued drought. Clear Lake elevations rebounded dramatically with a maximum for 1993 of 4,529.5 ft reached in May1993.

Clear Lake: Ecology

Because of shallow depths, mostly less than 2 m, and muddy sediments, Clear Lake is turbid owing to wind mixing; phytoplankton populations are low owing to high turbidity. Widely varying lake levels likely prevent growth of emergent vegetation. Macroinvertebrate diversity in the lake is low but densities are relatively high with oligocheats, chironomids, and nematodes dominating.

Densities of chironomids reached approx. 4,500 individuals/square meter in October (Parker et al. 2000). Zooplankton is dominated by rotifers, cladocerns, and copepods. Cladocern concentrations were found to peak in August with a density of approx.120 ind./l (Parker et al. 2000).

Clear Lake provides habitat for blue and tui chubs, marbled sculpin, lamprey, and large populations of both LRS and SNS (Buettner and Scoppettone 1991). The only plentiful exotic fish is the Sacramento perch.

Habitat use by suckers in the reservoir is poorly understood; however, Buettner and Scoppettone (1991) noted that suckers were most plentiful in the northeast section of the lake and were sparse elsewhere. Mammoth Springs on the southeast side of Clear Lake has been identified as a possible sucker spawning site but this is unconfirmed (Koch and Contreras 1973).

Clear Lake: Historic Sucker Population Status

Because there is no fish passage over Clear Lake Dam, it is apparent that suckers were present in the lake prior to completion of the dam in 1910. The earliest studies on suckers in Clear Lake were done in 1973 and 1974 by Andreasen (1975); only 59 specimens were reported. By that time the "mullet" snag fishery on the Lost River had ended. Collections made of LRS and SNS in Clear Lake between 1989 and 1993 showed a wide range of size classes, indicating fairly consistent recruitment (Buettner and Scoppettone 1990; Buettner and Scoppettone 1991; CDFG 1993; USBR 1994c).

Drought conditions in the Clear Lake watershed in the early 1990s temporarily reduced the habitat available for all fish. Clear Lake reached a minimum elevation of 4,519.2 ft, 28,380 acre-ft, in October 1992, the lowest elevation for this reservoir since 1935 and only 5% of the reservoir's total capacity (Service 1994b).. Populations of suckers in small reservoirs above Clear Lake may have been eliminated due to total or near complete desiccation during the summer of 1992, but probably were reestablished via spawning runs from Clear Lake in the spring of 1993 (M. Buettner, USBR, pers. comm.). There were strong spawning runs in 1993, but the low discharge of Willow Creek probably precluded any significant upstream migration in 1991 and 1992 (G. Scoppettone, USGS, pers. comm.). Large numbers of larval and juvenile suckers were observed in Willow Creek and tributaries during sampling in the spring and summer of 1993 (G. Scoppettone, USGS, pers. comm.). Researchers were unable to get a reliable population estimate of adult suckers in the 1993 spawning run due to sampling difficulties associated with ice conditions and high flows. Several LRS captured in Clear Lake in 1992 and 1993 exhibited signs of stress such as a noticeably thin appearance with sunken eyes, possibly the result of low lake levels and severe winter conditions (M. Buettner, USBR, pers. comm.). LRS and SNS captured in Clear Lake during late summer of 1993 appeared to be in relatively good condition (M. Buettner, USBR, pers. comm.), but condition factors for both species tended to be lower than those in Tule Lake (CDFG 1993).

The most recent status information on suckers in Clear Lake was done in 2000 by USGS (R. Shivley, USGS, pers. comm. 2000). They collected 155 LRS, ranging from 8-70 cm FL, and 339

SNS, ranging up to 49 cm FL. Although no aging has been done on these fish, the broad range of sizes suggests a diverse age structure.

Clear Lake: Tributary Spawning and Distribution

The only known spawning habitat for both Clear Lake endangered sucker species is found in Willow Creek and its tributaries (Buettner and Scoppettone 1991). Spawning runs at Clear Lake may occur from February to April, depending on ice and flow conditions (G. Scoppettone, UDGS, pers. comm.; M. Buettner, USBR, pers. comm.). In late spring of 1993, sucker larvae were found in the North Fork of Willow Creek where it crosses from Oregon into California, and in the headwaters of Fletcher Creek approximately 8 miles above Avanzino Reservoir near private land known as Mulkey Place (M. Yamagiwa, Modoc National Forest, pers. comm.). East Fork Willow Creek and Wildhorse Creek may be used by suckers for spawning but this has not been documented. SNS migrate prior to spawning as far as Fletcher Creek and its tributary Bayley Creek, 47 km upstream from the lake (Perkins and Scoppettone 1996). These fish were not from Avanzino Reservoir which was dry the previous summer. Some SNS in Clear Lake were tracked to near the mouth of Mowitz Creek but spawning there could not be confirmed (Perkins and Scoppettone 1996). Additional spawning information for both sucker species is given in a previous biological opinion (Service 1992a) and Buettner and Scoppettone (1990).

In the Clear Lake watershed there are more than 30 small reservoirs, many being <100 acre-ft in size, that serve as stock ponds. Most of these reservoirs are shallow and become choked with macrophytes in summer (Buettner and Scoppettone 1991). Water depth is likely to be highly variable in these ponds and most become dry in mid- to late-summer during droughts. Koch et al. (1975) found SNS in a number of these upstream reservoirs, including Wild Horse, Avanzino, Boles Meadow, Telephone Flat, and Bayley; the largest population was in Wildhorse Reservoir. Buettner and Scoppettone (1991) reported SNS distribution in Clear Lake tributaries to include Boles, Willow, and Fletcher creeks, and in reservoirs upstream of Clear Lake which contain water in most years, including: East, West, Lower, and Middle Fourmile Valley, Boles, Weed Valley, Wildhorse, and Avanzino, with most SNS coming from Avanzino Reservoir and upper Willow Creek. Most of the SNS found upstream of Clear Lake during the non-spawning season are likely age 0 fish; however, during wet climatic periods, SNS may mature in tributary streams and reservoirs. These SNS likely mature at a smaller size than they do in Clear Lake where food is more plentiful. Reoccurring droughts probably eliminate fish from most of these reservoirs but they are later reestablished from Clear Lake and any other refugial areas. Distribution survey data revealed LRS in the California reach of lower Willow Creek and Boles Creek upstream to Avanzino Reservoir (Buettner and Scoppettone 1991), and in Fletcher Creek approximately 8 miles above Avanzino Reservoir (Perkins and Scoppettone 1996). In a distributional survey of the Clear Lake watershed conducted in the summers of 1989 and 1990, LRS were collected in lower Willow Creek and Boles Creek upstream to Avanzino Reservoir (Buettner and Scoppettone 1991).

Clear Lake: Sucker Age and Growth

Preliminary analyses suggest that suckers in Clear Lake are relatively young. LRS in the Clear Lake drainage ranged up to only 27 years old (CDFG 1993), but sample sizes were limited and it

is likely that the maximum age for LRS in Clear Lake is greater than this (G. Scoppettone,USGS, pers. comm.). Maturity of Clear Lake LRS occurs at approximately age nine (G. Scoppettone, USGS, pers. comm.), and growth characteristics are currently being analyzed for Clear Lake suckers. Growth of LRS in Clear Lake has been assumed to be similar to UKL suckers, although growth rates can vary and could be slower in less productive waters like Clear Lake (G. Scoppettone, USGS, pers. comm.).

In Clear Lake, most SNS mature at age five (CDFG 1993). Ages of SNS from the Clear Lake watershed ranged from one to 23 years of age (Buettner and Scoppettone 1991), but sample sizes were limited, and it is possible that the maximum age for SNS in Clear Lake is greater than 23 years (Scoppettone, pers. comm.). The Clear Lake SNS population appears to have a much younger age structure than any other known population of this species (M. Buettner, pers. comm.). Sixteen year-classes were represented in Clear Lake in 1989 and 1990, with the largest group being five years of age (Buettner and Scoppettone 1993).

Gerber Reservoir: Sucker Population Status

Gerber Reservoir was built by damming Miller Creek in 1925 to provide flood protection and irrigation deliveries to about 17,000 acres in Langell Valley. Little is known about the ecology of the reservoir or of the SNS population in the reservoir. In May 1992, during the drought, over 200 SNS were salvaged. They ranged in size from about 8 to 46 cm FL. Monitoring since 1992 within the Gerber watershed has documented a substantial SNS population exhibiting a wide range of age classes. The presence of smaller suckers indicates the population in Gerber Reservoir has successfully recruited recently. While the population of SNS in Gerber Reservoir appears to have more frequent recruitment than some other populations, there is still the problem of restricted distribution and lack of genetic connectivity with other populations.

Reclamation monitored fish populations in Gerber Reservoir from April 1992 to June 1996. Trap nets and trammel nets were used to monitor fish on 6, 10, 16, 4, and 2 dates in 1992, 1993, 1994, 1995, and 1996 respectively (USBR, unpub. data). A total of 597 suckers > 28 cm FL were captured during these five years. Sucker catches (fish > 28 cm FL) by year from 1992-1996 were 199, 60, 288, 12 and 28 respectively. All larger suckers were tagged with either a floy anchor tag or PIT tag and released. Only one fish was recaptured (1995). Total sucker catches for 1992-1996 were 217, 160, 615, 14 and 28 fish respectively.

Most suckers collected ranged from 30-53 cm FL. However, the majority of the sampling effort was based on large mesh (2 inch stretch) trap nets and trammel nets. On several occasions, small-meshed (1 inch stretch) trap nets were used and many smaller-sized fish were captured (7-28 cm FL). Ages of 44 suckers, 30 of which were adults collected for genetic studies and the remainder mortalities from salvage operations below Gerber Dam documented 10 different year-classes. Fish ranged from 2-14 years old.

Sucker condition factors have varied considerably in the Gerber population. SNS captured in 1992 and spring 1993 were very thin compared to those from Clear Lake, Tule Lake and UKL, while SNS captured in 1994-1996 were substantially more robust. For example, based on a linear

regression analysis, a 40 cm FL fish in 1992 would weigh about 0.6 kg compared to about 0.8 kg in 1994 (USBR unpub. data). Extremely low water levels, high turbidity, and low DO concentrations may have contributed to their poor condition; however, the environmental conditions associated with the variability in condition factors have not been analyzed for the Gerber populations.

Gerber Reservoir: **Tributary Spawning and Sucker Distribution**

The timing and duration of flow events are highly variable in the Gerber Reservoir tributaries. Successful reproduction appears to be dependent upon coincidence of runoff events and spawning readiness (A. Hamilton, BLM, pers. comm.). Spawning usually occurs during periods of rapidly dropping hydrographs. All streams are reduced to isolated pools or very low flows by the end of May.

Barnes Valley Creek is the primary spawning tributary for the Gerber population and is the only available spawning tributary during low precipitation or low runoff years. Spawning activity has been monitored by BLM at the CCC road crossing annually since 1992 (USBLM 2000). Spawning migrations were documented in Barnes Valley Creek for all years. Information from these surveys suggests that peak adult migration occurs on about May 15 in most years. The duration of adult migration is estimated to be between three and four weeks, depending on flow conditions. Larval out- migration generally occurs between May 15 and June 5. Adult and juvenile suckers have not been observed in the project area between July and March. Spawning activity itself has been documented at or near the CCC Road crossing in the spring of all survey years except 1994, which was a year when stream flows were very low and of short duration. A concrete road crossing located in the lower portion of Barnes Valley Creek appears to have restricted passage under low flow conditions. BLM replaced the crossing in September 2000.

Additional visual observations have been made at specific locations over the course of a few dates each spring. The streams surveyed included Ben Hall, Long Branch, Pitch Log and Wildhorse Creeks. Sucker larvae were found in Ben Hall Creek in 1993, 1995, 1996, 1998, and 1999. Dry Prairie Dam located on Ben Hall Creek prevents passage to upstream spawning habitat during some years depending on the flows and the timing of the placement of dam boards. Intermittent streams are suspected of providing additional spawning habitat, based on past observations of suckers in the headwaters of Ben Hall Creek. Long Branch and Pitch Log Creeks, tributaries to Barnes Valley Creek had evidence of sucker spawning in only 2-3 years. No spawning or documentation of larvae was observed in Wildhorse Creek, where a waterfall near the inlet to Gerber Reservoir appears to be impassable. Another Gerber tributary, Barnes Creek, is a small tributary that does not support sucker spawning. This stream is seasonally dammed for irrigation and stock water purposes.

Apparently resident juvenile suckers (10-18 cm FL), either SNS or Klamath largescale, have been documented in several Gerber Reservoir tributaries including Ben Hall, Barnes Valley, Long Branch and Lapham creeks (A. Hamilton, BLM, pers. comm.). Adults appear to be frequently stranded in receding flows but a few may survive in the small stranded pools.

Miller Creek: Sucker Distribution and Status

Some suckers are entrained at the outlet of Gerber Dam. Sucker salvage operations were conducted below Gerber Dam in 1992, 1993, and 1997. In 1992, 229 suckers were captured and relocated to Gerber Reservoir. They ranged from 8 to 46 cm FL with considerable representation at sizes from 12.5 to 40 cm FL. In 1993 34 suckers were collected below the dam including about 20 age 0 suckers. Salvage operations in October 1997 as part of a Safety of Dams evaluation captured 152 suckers ranging from 8-47 cm FL. Most fish were 15-26 cm FL. Because of the risk of injury to personnel, salvage operations have been discontinued.

Downstream flows in Miller Creek are shut off at the end of the irrigation season, usually on October 1. A 1-2 cfs bypass is released into Miller Creek in winter to prevent the outlet valve from freezing. Before Miller Creek empties into the Lost River, flows are diverted into North Canal during the irrigation season. Thus little flow reaches the Lost River at any time of year. Some suckers are annually salvaged from North Canal. In 1999, substantial numbers of adult suckers were observed in the lower portion of Miller Creek, below East Langell Valley Road (B. Peck. USBR, pers. comm.). Twenty-one SNS were captured using a backpack electrofisher and about 20 additional suckers were observed but not captured on April 28. Suckers ranged from 34-47 cm FL and included 18 males and three females. All suckers were ripe. On April 29, another 15 adult SNS were sampled and/or observed from Miller Creek above the Wooden Bridge approximately 1mile upstream of the confluence of the Lost River. On May 4, 12 suckers were collected from several sites sampled between East Langell Valley Road and the mouth of Miller Creek. Small numbers (<10) of adults were observed through May 26. In 1998, SNS were observed spawning in the middle canyon area on April 26th (A. Hamilton, BLM, pers. comm.).

Sucker eggs were documented at several riffle areas in Miller Creek from East Langell Valley Road to the mouth on May 4, 1999 (B. Peck, USBR, pers. comm.). On May 20, sucker eggs were found at two riffle sites below the Wooden Bridge. Seven groups of larval suckers containing about a dozen fish each were observed in the backwater areas. Three locations with suitable gravel above the Wooden Bridge were checked for sucker eggs and none were found. No larvae were observed in this section. However, sucker larvae were common throughout the reach from East Langell Valley Road to the mouth on May 25.

Few observations were made above East Langell Valley Road and none above Miller Creek Dam during the 1999 sucker spawning run (B. Peck, USBR, pers. comm.). A rock and cobble check dam on private property downstream of the diversion dam may restrict or block upstream passage. On May 25 visual observations in backwater areas in North Canal failed to document any sucker larvae. But, larvae were found just below East Langell Valley Road on this date. Young-of-the-year juvenile suckers were observed throughout the year in lower Miller Creek. On May 17, 2000, dozens of juvenile suckers, 4-8 cm FL were sampled from the Willow Hole about 0.5 miles upstream from the mouth.

The sucker spawning run in Miller Creek was stimulated by the controlled release of water (470-490 cfs) from Gerber Reservoir between February 17 and April 23, 1999 to minimize the risk of flooding (USBR unpub.). In 2000, no water was released from Gerber Reservoir prior to

irrigation season and suckers were not observed spawning in Miller Creek. Flows in lower Miller Creek ranged from approximately 5-10 cfs during the spawning season (March – May). At these lower flows, passage may be restricted by the shallow water depths (2-3 inches) at the mouth of Miller Creek. During late spring and summer, passage improves as water levels in the Lost River increase due to agriculture return flows. Spawning access and habitat may be improved through constriction of the stream channel at the mouth.

Lost River: Historic and Current Sucker Habitat Conditions

Aquatic habitats throughout the upper Klamath Basin are highly modified, but the Lost River has perhaps been the most severely affected. As mentioned above, the Lost River was once a major spawning site for suckers. Modoc and Klamath Indians gathered along the Lost River during the spring spawning runs to harvest suckers. Later it was the site for several canneries. However, today the Lost River supports few suckers, and furthermore, can perhaps be best characterized as an irrigation water conveyance, rather than a river. For nearly its entire 75 mile length, from Clear Lake Reservoir to Tule Lake Sump, the Lost River is highly modified to meet agricultural demands. Flows are completely regulated, it has been channelized in one 6 mi reach, its riparian habitats and adjacent wetlands are highly modified, and it receives significant discharges from agricultural drains and sewage effluent. The active floodplain is no longer functioning except in very high water conditions. This has likely affected wetlands and wet meadows and may have resulted in lowered water tables, further increasing the need for irrigation.

Numerous water-diversion structures are located on the Lost River including Malone, Big Springs, Harpold, Lost River Ranch, Lost River Diversion, Lower Lost River Diversion (Wilson Dam), and Anderson Rose dams. There are also numerous unscreened pumping plants that remove water, and drains that receive irrigation return flows. Unscreened UKL water can be diverted into the Lost River at several points, and Lost River water can be diverted to the Klamath River via the Lost River Diversion Canal. Consequently flows are highly modified both in timing, quantity, and quality (Orlob and Woods 1964). It is possible that flows may even reverse when water is being pumped from river. The Lost River was historically connected to the Klamath River during high flows via the Lost River Slough, as discussed below (Gilbert 1898). The Lost River Diversion Canal was constructed at the location of that slough.

Owing to irregular and unplanned irrigation withdraws from the Lost River, water levels in the river may rapidly fluctuate leading to bank instability and slumping, fish are likely stranded, and fish habitat quality is much reduced. Flows in the upper reach of the Lost River, from the Clear Lake Dam to the confluence with Rock Creek, are cut off from October to April during the non-irrigation season, with the only flows coming from accretion primarily by small springs and Rock Creek. During this time, fish are confined to any remaining pools and are thus likely subjected to high predation, a lack of food, and poor water quality (Contreras 1973; Koch and Contreras 1973). DO levels measured in September 1999 after flows were cutoff at Clear Lake Dam were <4 ppm in pools (USBR, unpub. data). Downstream reaches, such as below Malone Dam, can have much reduced flows in summer as water is diverted from the river into West Canal, and Miller Creek flows diverted to North Canal. A number of small pumping plants are also withdrawing water from the Lost River. How many of these diversions are unscreened is unknown but it is likely that

few have adequate screens or even any modifications to reduce or minimize fish entrainment except for the largest fish.

Several large springs (e.g., Big Spring, Bonanza Spring, Crystal Spring) contribute significantly to baseflows. Big Springs, east of Bonanza, contributes about 70 cfs of artesian flow to the Lost River (Orlob and Wood 1964). There are anecdotal reports of the Lost River not flowing in late summer prior to construction of Clear Lake and Gerber dams. Although possible, we have not been able to confirm this.

The highly modified nature of the Lost River is expressed in its aquatic fauna, which include many exotic, warm-water species and is dominated by highly tolerant chubs (Contreras 1973; Koch and Contreras 1973). Of the 16 fish species known from the river, 9 are non-native, warm-water fish. Koch and Contreras (1973) identified four distinct river segments, based on fish distribution and abundance: 1) upper Lost River, upstream of Bonanza, which is largely devoid of fish because of channelization and shallow depths owing to water diversions; 2) Big Springs to Harpold Dam which contains the best fish habitat owing to significant input of spring water and suitable habitat; 3) Crystal Springs Reservoir above Lost River Diversion Dam, which also has a relatively high diversity of fish; and 4) lower Lost River, characterized by low fish diversity. A fifth reach might be added between Malone Dam and Clear Lake. This reach is a high gradient reach which is dewatered in winter when flows are cutoff at Clear lake Dam. Reaches of the Lost River with relatively high fish diversity can be described as having adequate flows, better than average water quality, and better habitat or greater habitat diversity.

During the irrigation season, Miller Creek is diverted into North Canal. Annual salvage of large numbers of redband trout from North Canal by Reclamation fish biologists (Peck 2000) suggests that high quality water is being released upstream at Gerber Dam. Ironically North Canal in the irrigation season now has some of the better stream habitat for fish in the Lost River system; the best habitat is in the Miller Creek canyon managed by BLM.

Lost River: Water Quality

High temperatures, low DO, elevated nutrients, and high levels of suspended sediments are considered to be problems in the Lost River. The Lost River is listed by the State of Oregon, on its 303(d) list, for several water quality parameters that exceed state limits including: DO, pH, temperature, bacteria, and chlorophyll-a (Chl-a). Koch and Contreras (1973) noted that temperatures in April were highest in the upper Lost River below Clear Lake Dam and Langell Valley where flows were low owing to a lack of dam releases. Koch and Contreras (1973) noted that in Langell Valley, where the river is channelized and flows reduced by diversions, the river flow is considerably reduced and habitat is lacking.

Reclamation has conducted water quality monitoring at up to 17 locations in the Lost River between Malone Dam and Tule Lake from 1992 to the present (USBR unpub. data). Between 1992-1998, biweekly to monthly profile data were collected using datasonde water quality instrumentation that continuously monitored temperature, DO, pH, and conductivity. Reclamation has also collected more detailed water quality information quarterly at Anderson Rose Dam and

Wilson Reservoir since 1980 and twice a year (May and August) at Malone Reservoir and Miller Creek Dam. Water quality constituents included: air temperature, water temperature, DO, pH, conductivity, ammonia, nitrate + nitrite N, orthophosphate, total phosphorus, Kjeldahl nitrogen, total dissolved solids, alkalinity, boron, mercury, turbidity and arsenic.

Beginning in May 1999, Reclamation expanded its' water quality monitoring program in the Lost River sub-basin to provide more detailed baseline information on selected water quality parameters on both a seasonal and spatial scale (Shively et al. 2000b). Water quality sampling is proposed to continue through May 2001. Sampling occurs every two weeks at 13 sites along the course of the Lost River. A detailed analysis of this data has not been completed, but it was found that DO levels were below State of Oregon standards of 5.5 mg/l at all stations except North Canal, which gets its water from Miller Creek. DO levels were lowest in Wilson Reservoir, where they were near 1 mg/l, but were also low at other stations downstream from Wilson, including #5 Drain, Anderson Rose, and East/West Bridge. It can be concluded that water quality in the Lost River limits habitat for all fish, including LRS and SNS, and can be seasonally lethal.

Lost River: Status of Suckers

The Lost River currently supports very small numbers of LRS and SNS, with SNS predominating. Suckers, almost exclusively SNS, have been reported from just below the Clear Lake Dam; lower Antelope Creek; Malone Reservoir; Big Spring to Harpold Reservoir; and below Anderson Rose Dam (Koch and Contreas 1973; Buettner and Scoppettone 1991).

Sucker spawning habitat in the Lost River is very limited. Sucker spawning has been documented below Anderson-Rose Dam, in Big Springs, and at the terminal end of the West Canal as it spills into the Lost River. Suspected spawning areas that have suitable habitat (rocky riffle areas) include the spillway area below Malone Reservoir, just upstream of Keller Bridge, just below Big Springs, just below Harpold Dam, and adjacent to Station 48. In April 1992, Mark Buettner, USBR, observed an estimated 100 SNS spawning in Big Springs; one month later larvae were observed there (M. Buettner, USBR, pers. comm.). According to residents, sucker spawning at Big Springs is rare. Spawning at Anderson Rose Dam is described below. Spawning has also been documented in Miller Creek, and is suspected in Buck Creek. Several adult suckers were captured near the mouth of Buck Creek in June and juvenile suckers were captured in Buck Creek (USBR unpub.). This suggests there may be restoration opportunities in the Buck Creek area.

Lost River: Sucker Status - Clear Lake Dam to Bonanza

Reclamation has collected a few LRS and SNS each year during salvage operations immediately below Clear Lake Dam. These fish were released in the Lost River at Stevenson Park near Olene. Few suckers are believed to occupy the 8-mile reach between Clear Lake Dam and Malone Dam owing to the high gradient and lack of pool habitat. Additionally flows in this reach are highly variable, being high in summer during irrigation releases and being low the remainder of the year when halted at the end of irrigation season.

Malone Reservoir is not believed to support a viable sucker population, but instead probably contains waifs entrained into the Lost River from Clear Lake (Buettner and Scoppettone 1991). In 1992, 350 SNS and 4 LRS were salvaged at Clear Lake and placed in Malone Reservoir by Reclamation staff.

On April 13, 1992, four trap nets (1-inch stretch) were set overnight in the Lost River between Malone Dam and Keller Bridge in the Langell Valley area. No suckers were captured in this shallow, low gradient channelized river section that averaged about 2 ft deep. Very little flow was documented in this reach and no water was being released from Malone Reservoir. Four trap nets were set overnight in Malone Reservoir on the Lost River, at the upper end of the Langell Valley on July 30, 1992. Two adult SNS, 37 and 43 cm FL, were captured.

Reclamation monitored sucker populations in the Lost River on a few occasions in 1992. Approximately 100 SNS were observed at Big Springs in Bonanza on April 7 and 8, 1992. Thirteen were captured ranging from 38 to 49 cm FL. Four spawning sites were identified in the springs. Water depths at spawning sites ranged from 1.2 to 2.4 ft and bottom substrate consisted mostly of gravel and small cobble. Water quality at the spawning areas included: water temperature 16.3-16.5 C, pH 8.0-8.1, DO 7.3-7.8 mg/l, and conductivity 157-158 uS/cm. Sucker eggs were observed in the substrates. About 4 weeks later hundreds of sucker larvae were observed in the springs.

On April 14, 1992, an electrofishing survey was conducted from Keller Bridge to Bonanza using a boat electrofisher. Ten adult suckers were captured and about 10 additional fish were seen but not collected. Most suckers were sampled from deeper pools about 2-4 miles below Keller Bridge. On September 16, 1992, three adult SNS were captured 0.2 miles above Big Springs.

On April 26, 1995, seven juvenile suckers were captured in the Lost River adjacent and downstream of Big Springs using a backpack electrofisher. These fish ranged from 12 to 23 cm FL. One adult SNS 48 cm FL was captured and radio-tagged. On May 23, 1995, trammel nets were fished for 2-5 hours in at Harpold Road below Big Springs; one adult SNS , 38 cm FL was captured. Reclamation tracked the radio-tagged suckers at 1-2 week intervals throughout the summer. One of the Big Springs area fish was located about a mile upstream of Big Springs on May 24, 1995. Over the next two weeks it was located in the Lost River near Buck Creek. By July 19 it was located just downstream of Big Springs where it remained into August when monitoring stopped.

In October 1998, Reclamation staff collected SNS in North Canal, operated by Langell Valley Irrigation District (Peck 1999). In April 1999, SNS in spawning condition were observed by Reclamation biologists in Miller Creek below East Langell Valley Road (Buettner 1999). Additional SNS were collected in Miller Creek about 1 mile above the confluence with the Lost River. These observations indicate that a small, resident population of SNS is present in Miller Creek. Whether or not this is a self-reproducing population is unknown since fish are likely entrained at Gerber Dam and move downstream.

Reclamation conducted sucker radio tracking in the Lost River in March-June 2000 (USBR, unpub.

data). Adult suckers were captured throughout the Lost River with the majority captured in the Harpold reach and Wilson Reservoir as was noted in 1999. Very few fish were captured between Wilson Reservoir and Anderson-Rose Dam. Twenty-four adult suckers were implanted with radio-tags between April 28, 1999, and May 6, 2000. They included 14 females, 9 males, and 1 of unknown sex. They were radio-tagged and released at six locations on the mainstem Lost River and Miller Creek. Four were caught in Miller Creek on April 28, 1999. These suckers moved out of Miller Creek during May and resided in the Lost River between Keller Bridge and Big Springs through September 1999 when tracking ceased. On April 20, 2000, one of the tagged fish was located below Big Springs diversion dam.

Lost River: Sucker Status - Bonanza to Olene

In 1999, Reclamation and USGS conducted a more detailed fish monitoring effort on the Lost River and selected tributaries from June 11 to October 5 (Shively et al. 2000b). Adult suckers were captured throughout the river system, although the majority of suckers were captured in the Harpold reach above Harpold Dam. A total of 105 suckers were captured. Only one LRS was captured while the remainder were SNS. Based on length frequency distributions it appears that several year classes were represented within the Lost River. Juvenile suckers were also captured throughout the Lost River. Most juveniles were captured in the Harpold Reach, Keller Bridge, and at the confluence with and within Miller Creek.

During the 1999 radio-telemetry study by Reclamation, three suckers were caught between Harpold Dam and Big Springs Dam on May 26. All three remained in this reach through September 1999. The last date a fish was located was June 16, 2000. In 2000, three suckers were caught at the mouth of Buck Creek on May 4. These fish appeared to be in a post-spawning condition. They all remained in the reach between Harpold and Big Springs Dam until August 18, the last date fish were tracked.

In spring 2000, three adult suckers were implanted with radio tags and released in the Lost River reach between Lost River Ranch Dam and Harpold Dam. Two of these fish have stayed in this reach until August 18, and one fish has not been located since June 9. It is not clear whether these fish spawned in the mainstem Lost River. Boards at Harpold Dam were put into place in late April and may have prevented upstream movement of the fish.

It is possible that some suckers in this reach of the Lost River originated in UKL, since UKL water, transported down A-Canal, reaches as far as the Poe Valley.

Lost River: Sucker Status - Olene to Tule Lake Sump

May 23, 1995, trammel nets were fished for 2-5 hours in Wilson Reservoir; one SNS , 41 cm FL, was captured and radio-tagged. On May 26, 1995, four trammel nets were fished for 3-4 hours in Wilson Reservoir. Eight adult SNS, all females ranging from 40 to 47 cm FL, were captured. The sucker fitted with a radio tag remained in the reservoir.

Three suckers were captured in Wilson Reservoir and implanted with radio tags on March 22,

2000. By April 5 two fish had moved upstream of Wilson Reservoir into a narrower section of the Lost River. All three were upstream of the reservoir on June 2 and stayed there at least until July 20. None of these fish entered into tributaries during the spawning season and passage was blocked at the Lost River Ranch Dam during late April, possibly prohibiting upstream movement of these fish. Two suckers were captured below Horseshoe Dam on April 4 and April 13, 2000. Both fish remained in this reach until July 20, the last date of tracking.

Lost River: Sucker Status - Lost River Diversion Channel

The Lost River Diversion Channel (LRDC) presently can flow either east or west, depending on water demands within the Project. In winter (non-irrigation season), almost the entire Lost River flow is diverted into the LRDC at the Wilson Reservoir dam. These waters then flow downstream into the Klamath River. Winter flows that exceed the capacity of the LRDC are spilled into the historic Lost River channel, which flows into the Tule Lake sumps. As the irrigation season begins in spring, the station 48 canal, which lies east of the proposed project site and withdraws water from the LRDC, fills and provides delivery of irrigation waters to areas south of Klamath Falls. When station 48 summer water demands exceed westward flowing LRDC flows, excess irrigation demands are met with water that is withdrawn from the Klamath River. Thus, Klamath River waters typically flow eastward through the project site when irrigation demands are high (e.g., late spring-summer) and Lost River waters flow westward through the project site when irrigation demands are minimal and after the growing season (e.g., early November through March). In addition, waters from UKL may enter into the Lost River system, and thus into the LRDC, when excess and return flows drain back into the Lost River watershed from the B, E, and F irrigation canals. All of these water bodies may transport endangered suckers since none are screened.

While the LRDC does not provide the lacustrine habitat that is preferred by these lake suckers, water quality conditions in the Lost River's near Wilson reservoir may seasonally be very poor and may cause migration out of the reservoir and into the LRDC (B. Peck, USBR, pers. comm.). The overall connectedness of Klamath Project water bodies suggests that endangered fish could easily gain access to the LRDC, but once in the channel, there is very little information upon which to predict the site-specific density of endangered suckers.

Although no recent fish surveys have been conducted in the LRDC, limited sampling was done by Contreras in 1973. In his Master's thesis, Contreras (1973) reported sighting several sucker specimens and dip netting two SNS from the LRDC pool below Wilson reservoir. He also gill netted one SNS from the LRDC at a site approximately ¼ mile west of the Wilson Reservoir gates at the C-G foot bridge. His surveys, however, were not comprehensive and his gill netting was limited in duration because heavy algae blooms clogged his sampling gear. More recent A-canal fish sampling has determined the presence of suckers at the headworks of the A-canal (Gutermuth et al. 2000) and 8.6 miles downstream at the B-C split (Gutermuth et al. 1998). During the period 1996 through 1998, these monitoring efforts revealed that the highest density of juvenile suckers were present in the canals after August. In addition, several fish kills and collection efforts in Wilson Reservoir, directly upstream of the LRDC (approximately 2.5 miles), have also recovered both juvenile and adult endangered suckers (USBR unpub. data). Fish may move between any of

these Klamath Project irrigation locations via unscreened headgates, pipes, and diversions. A summary of unpublished Wilson Reservoir collection and observation records follows:

During late January and early February of 1997, a relatively small fish kill occurred in the southern end of Wilson Reservoir near the LRDC head gates. A minimum of 55 juvenile suckers (86-188 mm FL), of unidentified species, were apparently killed when DO concentrations dropped to lethal levels (<1 mg/l measured by Reclamation biologists on 2/5/97) below an ice cover.

In late August and early September of 1999, a summer fish kill occurred in the LRDC below the Wilson Reservoir headgates. It is presumed that low oxygen conditions caused this kill when anoxic waters from the bottom of the thermally stratified Wilson reservoir were mixed upward and delivered to the LRDC. Collections of dead fish from that period included only tui chubs (*Gila bicolor*), however abundant fish eating birds (e.g., Caspian and Forster's terns, great egrets, etc.) were present and may have consumed any juvenile suckers. In two days of June 1999 trammel netting (6/16 and 6/18/99), a total of 22 adult endangered suckers were captured and pit tagged from Wilson Reservoir. These fish ranged in size from 30 to 49 cm FL (B. Peck, USBR, pers. comm.). During a June (6/24/99) overnight trap net set in Wilson Reservoir, over 600 fish (mostly brown bullhead (*Ameiurus nebulosus*) and pumpkinseed sunfish (*Lepomis gibbosus*) were collected (B. Peck, USBR, pers. comm.). In this trap netting effort, a method usually employed in efforts to catch small fish (<15 cm FL), no suckers were captured. On September 24, 1999, brown bullheads were the only fish collected during five Wilson reservoir trammel net sets (B. Peck, USBR, pers. comm.).

On March 22, 2000, five trammel nets were set in Wilson Reservoir. From these nets, a total of 12 suckers between 36 and 52 cm FL were collected (B. Peck, USBR, pers. comm.). These suckers included SNS, Klamath largescale suckers, and many that exhibited morphology identified as intermediate between these two species. All were pit tagged and four were radio tagged for telemetry studies. To date, these radio tags have not shown that adult suckers move downstream of Wilson Reservoir (B. Peck, USBR, pers. comm. 2000). In one day (4/26/00) of spring trammel netting at the Olene gap on the Lost River, upstream of Wilson reservoir and the LRDC, two Klamath largescale suckers were collected, 41 and 43 cm FL (B. Peck, USBR, pers. comm.).

Tule Lake Sumps

Historical Account

Historically, Tule Lake covered a maximum area of about 95,000 acres (Abney 1964), making it about the same size as UKL, before diking and draining reduced its surface area. Tule Lake is the terminus of Lost River, but historically, flood flows from the Klamath River would also enter Tule Lake by way of Lost River Slough. Lost River got its name from the fact that it did not directly connect to the sea.

In the 1880s, white settlers built a dike across the Lost River Slough in a first attempt to reclaim Lower Klamath and Tule lakes. Reclamation began actively reclaiming historic Tule Lake with

the construction of Clear Lake Dam in 1910 and the Lost River Diversion Dam in 1912 (USBR 1953). In 1932, a dike system was constructed to confine the drainage waters entering Tule Lake to a central sump of about 10,600 acres. In 1937, maintaining the dike system became difficult as heavy inflows required an additional 3,400 acres of surrounding lands to be flooded. In 1938, the sump was increased to 21,000 acres. During the winter of 1939-40, heavy inflows entered the sump again and dikes broke, flooding an additional 2,400 acres and damaging crops. Thus, it became necessary to control the level of Tule Lake by installing a pumping station.

In 1942, a 6,600 foot-long tunnel through Sheepy Ridge and Pumping Plant D were completed, allowing water to be pumped from Tule Lake into Lower Klamath Lake (USBR 1941). This pumping station provides flood control for Tule Lake and is now the primary source of water for Lower Klamath NWR.

The present Tule Lake is highly modified and consists of two shallow sumps, 1A and 1B, connected by a broad canal, the "English Channel." The two sumps have a surface area of 13,000 acres and a maximum depth of 3.6 ft. Water entering Tule Lake comes from three sources: (1) direct rainfall, (2) agricultural return water, and (3) the Lost River. In winter, most of the Lost River flows are diverted at the Lost River Diversion Dam to the Klamath River via the Lost River Diversion Channel. In the irrigation season, this channel is also used to supply water from the Klamath River by reverse flow for lands in the Tule Lake area. Therefore, most of the water entering Tule Lake during the irrigation season originates from UKL, via the Klamath River in the Lake Ewauna area. The total mean annual inflow into Tule Lake is about 90,000 acre/ft (Kaffka, Lu, and Carlson 1995).

Critical habitat for the suckers has been proposed for Tule Lake sumps 1A and B and upstream on the Lost River to the Anderson-Rose Dam (Service 1994). In designating this area as proposed critical habitat the Service thought that Tule Lake could support viable, self-reproducing populations of LRS and SNS. If habitat in Tule Lake sump is not improved, the ability of the existing sucker populations to be self-reproducing is questionable.

Water level elevations in Tule Lake sumps has been managed according to criteria set in the 1992 BO. From April 1st to Sept. 30, a minimum elevation of 4034.6 ft was set to provide access to spawning sites below Anderson Rose Dam for dispersal of larvae and to provide rearing habitat. For the rest of the year, October 1 to March 31st, a minimum elevation of 4034.0 ft is set to provide adequate winter depths for cover and to reduce the likelihood of fish kills owing to low DO levels below ice cover.

Tule Lake Sumps: Ecology

Although no recent comprehensive biological surveys exist for Tule Lake sump 1A, general field observations by refuge biologists indicate that the plant community is composed of *Scirpus acutus, Scirpus fluviatilis, Typha latifolia, Sago pectinatus, Ceratophyllum demersum, Zannichellia palustris, Myriophyllum* and *Lemna* spp. (Dave Mauser, Service, pers. comm.). Abney (1964) reported that the marsh consisted of 80% bulrush, 14% cattail, 5% river bulrush with smaller amounts of giant bur-reed, sedges and rushes.

Phytoplankton surveys from UKL (Bond et al. 1968; Gahler 1969; Hazel 1969 and Johnson 1985), a primary water source for Tule Lake NWR, provide indications of phytoplankton species that exist in Tule Lake. Invertebrate surveys in Tule Lake sump 1A report the presence of coelenterata; nematodes; annelids including oligochaeta and hirudinea; mullusca including gastrapoda; arthropods including crustacea (copepoda, conchostraca and amphipoda) and chelicerata; and insecta including ephemeroptera, odonata, trichoptera and diptera (chironomids and tipulidae). General field observations by refuge biologists indicate the presence of other species including hemiptera (Dave Mauser, Service, pers. comm.). Dietary studies from endangered suckers in Clear Lake NWR (Scoppettone 1995), a secondary water source for Tule Lake NWR, indicate that endangered suckers in Tule Lake consume invertebrates, including cladocera (*Daphnia* spp.), ostracoda, copepods, amphipod, and oligochaete worms.

Tule Lake Sumps: Historical Account of Sucker Populations

Historically the Lost River had very significant runs of suckers, apparently originating from Tule Lake. The Modoc Indians and white settlers ate suckers or used them for livestock food (Cope 1879; Coots 1965; Howe 1968). Sucker runs up the Lost River were once so large that several canneries were set up to can and process suckers into dried fish, oil, and other products (Howe 1968; Andreasen 1975). LRS are known to be native to the Lost River system. The presence of the SNS in the Lost River drainage prior to construction of the Lost River Diversion Canal by Reclamation in 1912 has been questioned (Williams et al. 1985; Moyle 1976; Scoppettone and Vinyard 1991; Service 1993a). However, the presence of SNS in Clear Lake indicates they were native to the Lost River system since the dam, built in 1910, lacks fish passage. SNS were also present in the Miller Creek system prior to closure of the Gerber Dam in 1925.

Today, water, and entrained fish, from the UKL and the Klamath River are now diverted into Tule Lake via Lost River Diversion Channel. Consequently, suckers in Tule Lake may now consist of mixtures of stocks from both the Upper Klamath and Lost River drainages. Genetic studies are needed to determine the origin of the suckers now residing in Tule Lake.

Suckers have been only recently rediscovered in Tule Lake sumps. The lake was sampled for suckers in 1973, but none were collected (Koch and Contreras 1973). However in 1991 both species were observed spawning below Anderson-Rose Dam, and in 1992-93 about 20 specimens of each species were captured in Tule Lake (Service 1993a). The negative results of Koch and Contreras is likely explained by limited collecting effort in areas where suckers aggregate and low sucker population levels. It seems unlikely that suckers have only recently re-invaded the sumps via entrainment of fish into irrigation canals.

Scoppettone, Shea, and Buettner (1995) studied fish, including suckers, in Tule Lake sumps from 1992 to 1994. Tui and blue chubs predominated, with relatively few suckers being collected. Mark and recapture techniques were used to estimate the sucker populations, however in nearly 3,000 trap hours only 67 suckers were collected. All fish were tagged and released, but only one recapture was made for each species. Based on this very limited capture and recapture data, the estimated number of shortnose adults was 159 with a 95% confidence interval (CI) of 48 to 289 suckers. Only 105 LRS were estimated with a CI ranging from 25 to 175. While an accurate

estimate of the population size was not possible, the available data suggests that sucker population sizes in Tule Lake are small. Suckers collected in this study were represented by few size classes with those of about 46 cm FL predominating for SNS, and those 46-60 cm FL for LRS (Scoppettone, Shea, and Buettner 1995). Suckers inhabiting Tule Lake were also found to have a high condition factor (ratio of weight to length) relative to that of other Klamath Basin sucker populations. Adult suckers captured in Tule Lake had fewer external parasites and were larger and heavier than suckers from Clear Lake and Gerber Reservoir. No lamprey parasitism was observed.

In 1999, trammel nets were set in Tule Lake on two occasions, April 2 and 9, in the northwest corner for 1-2 hours. On April 2, seven Lost River and two SNS were captured from five nets. On April 9, three SNS and two LRS were captured from 7 net sets of 1-2 hours. One SNS originally tagged in 1993 was recaptured. On April 7, 2000, the Service (Klamath Basin NWR) set three trammel nets in the northwest corner and two nets in the English Channel for 2-3 hours. Five LRS and 11 SNS were captured in the northwest corner and six LRS and four SNS were captured in the English Channel. Two of the LRS were fish marked in previous years.

Sucker Spawning in Lower Lost River

Populations of suckers in historical Tule Lake migrated up the Lost River to spawn at Big Springs (River Mile 42), near Bonanza, Oregon and probably other shallow riffle areas with appropriate spawning substrate (Coots 1965 and Klamath County 1976). The construction of Lost River Diversion Dam in 1912 by Reclamation restricted sucker migrations to the lower 23 miles of the Lost River. In 1921, construction of the Anderson-Rose Diversion Dam further restricted migrations to the lower 7 miles of the river.

Reclamation has monitored endangered sucker spawning runs from Tule Lake into the Lost River annually since 1991 (USBR 1998c). Although dozens of suckers were observed spawning during May each year and eggs were found in the substrate, substantial numbers of larval suckers have only been observed in 1995. However, since no intensive larval emigration sampling has been conducted it cannot be concluded that spawning failed completely in the other years. However, Reclamation believes that enough visual observations were made during most years to detect good larval sucker survival had it occurred. The apparent lack of spawning success in most years appeared to be related to the lack of adequate spawning habitat. Reclamation monitored water quality during both years and found that temperature, DO, pH, and specific conductance were adequate for sucker spawning and incubation. However, relatively high concentrations of ammonia have been monitored in this area that may contribute to the low survival (USBR, unpub. data). In 1995, Reclamation constructed a spawning channel below Anderson Rose Dam and added gravel to a known spawning riffle. The spawning channel did not appear to be used although fish were observed in it. In 1996, the channel washed out under high winter flows. The channel was not rebuilt.

Beginning in 1999, Reclamation changed operations in the Lost River below Anderson Rose Dam. Specifically, releases of 30 cfs were started on April 15 and continued until spawning and incubation were complete in early June. Previously, releases of 50 cfs were required beginning

April 1 and continuing for at least four weeks (1992 BO). Observations in 1995, 1999, and 2000 by Reclamation biologists show that releases of 30 cfs may be adequate for sucker passage up to and spawning below Anderson Rose Dam. In 1999, suckers began migrating to the dam as early as two days after releases were started. In 2000, the first suckers were observed April 21, 6 days after the April 15 start date.

In 1994, the U.S. Fish and Wildlife Service attempted to collect transect data for physical habitat simulation modeling (PHABSIM) but stopped after they found that a backwater effect influenced the river's water levels. It appears that aquatic plant growth in the river is a major factor affecting water levels. This growth increases throughout the spring leading to greater resistance to flow and higher water levels. Tule Lake sump elevation and agricultural return flows below Anderson Rose Dam also affect river water levels.

Critical habitat for the suckers has been proposed for Tule Lake sumps 1A and B and upstream on the Lost River to the Anderson-Rose Dam (Service 1994). In designating this area as proposed critical habitat the Service indicated their opinion that Tule Lake could support viable, self-reproducing populations of LRS and SNS.

Tule Lake Sumps: Sucker Habitat

Sucker habitat in Tule Lake for juveniles and adults is limited because of shallow depths in both sumps. The sumps have been filling with sediment. Approximately 8,000 and 5,000 acre-ft of storage were lost from sumps 1A and 1B, respectively, between 1958 and 1986 (USBR unpub. data). Wind- and water-borne silt is coming primarily from agriculture in the Lost River watershed (Service 1998c). Since Tule Lake sumps are shallow, with an average depth of less than 4 ft, this loss of habitat is significant. There is also evidence that both sumps have filled in substantially over the last several decades due to sedimentation (Hicks et al. 2000). Reduction of water depth in Tule Lake is a threat to the suckers because it increases the risk of winter freeze, reduces the amount of deepwater habitat for adult suckers, increases avian predation of suckers, and may contribute to poor water quality by allowing the water to heat more rapidly and allowing sediments and nutrients to be more readily mixed by wind shear. Adoption of better soil management practices would likely reduce the rate of sedimentation. The Refuges are developing a plan of sump rotation that may help alleviate the problem of siltation in Tule Lake, however, sediment transported by the Lost River will continue to be a problem until erosion in the Lost River watershed is reduced.

Rearing habitat in the Lost River downstream of Anderson-Rose Dam is limited both by water quality and structural features of the channelized river. The lower Lost River is, at high lake levels, made up almost entirely of backed-up sump water, and water quality conditions reflect those in the sump. A few small irrigation return drains empty into the river in this reach and may contribute to water quality degradation.

Tule Lake: Water Quality

Tule Lake is classified as highly eutrophic because of high concentrations of nutrients and resultant elevated aquatic plant productivity (Winchester et al. 1994; Dileanis et al. 1996). Because Tule Lake is shallow and the nutrient content is high, aquatic plant and phytoplankton activity cause large fluxes in levels of DO and pH.

During the irrigation season, water reaching the sumps has been used an average of three times by being applied to agricultural lands (Orlob and Woods 1964). Tule Lake water quality is affected by its various sources of inflow. During the irrigation season, the primary source is UKL, via the Lost River Diversion Canal and A-canal. UKL is highly eutrophic as discussed previously, with large, near-monoculture blooms of the cyanobacterium (formerly termed, blue-green alga), *Aphanizomenon flos-aquae* (*AFA*) occurring almost continuously from spring through fall (Kann 1998). Associated with the blooms are extreme water quality conditions such as high pH and low DO levels (Dileanis, 1996). Water from Clear Lake and Gerber reservoirs also flow into Tule Lake sump 1A through the Lost River after receiving agricultural return water from the Langell Valley, Horsefly, Poe Valley, Klamath and Tule Lake Irrigation Districts. Agricultural return flows contain higher concentrations of dissolved salts including sulfates and nitrates, as well as ammonia and pesticides, than the source waters.

Water quality can vary greatly both seasonally and diurnally, especially in summer. Due to the lake's shallowness and high biomass of aquatic macrophytes and filamentous green algae during summer, DO and pH levels fluctuate widely. During the winter, most inflow to Tule Lake is from localized runoff. Water quality conditions during this time of year are relatively good, except during prolonged periods of ice-cover when DO levels decline. Reclamation has documented surface temperatures up to 26E C, and DO levels from super-saturation, >15.0 mg/l, to near zero; pH occasionally exceeded 10.0 (USBR, unpub. data).

Specific conductance in Tule Lake is high, up to about 1,000 umhos/cm, compared to UKL (120 umhos/cm). This increase is due to salts leached from soils in agricultural return flows and from bottom sediments of Tule Lake. High rates of evaporation (over 3 ft per year) in the shallow and warm sumps also increases salt concentrations. Salt concentration, however, does not appear to be an immediate threat to LRS and SNS. In Pyramid Lake, where specific conductance is nearly 6.5 times higher than Tule Lake, another lake sucker, the cui-ui, *Chasmistes cujus,* thrives. The cui-ui and other lake suckers similar to the LRS and SNS have apparently evolved in habitats with high conductivities and appear to be tolerant of such conditions (Miller and Smith 1981). The high salt content of Tule Lake waters also may explain the low incidence of fish parasites (E. Snyder-Conn, Service, pers. comm.).

Bioassays have shown that agricultural drain water and water within Tule Lake sumps is seasonally toxic, owing to low DO and high pH and ammonia levels, to some test aquatic organisms including *Daphnia* sp. and the fathead minnow, *Pimephales promelas* (Littleton 1993; Dileanis et al. 1996). In 1991 and 1992, Dileanis et al. (1996) found that un-ionized ammonia concentrations were at potentially toxic levels in water sources, drains and receiving waters around the Tule Lake sumps, but the sumps produced the highest percentage of values above the

EPA criteria 0.02 mg/L (depending on pH and temperature). Over the short term, the frequent low DO levels in Tule Lake sumps may pose the number one threat to aquatic life, including fish (Snyder-Conn, Service, pers. comm.). However, in the long term, decreases in water depth in Tule Lake sumps may pose the greatest threat to the endangered suckers. Between 1958 and 1986, approximately 30%, or 14 inches, of depth was lost in the sumps.

Although a variety of pesticides have been detected in waters and sediments around Tule Lake, the levels are below those known to be acutely toxic to aquatic life (Dileanis et al. 1996).

Tule Lake Sumps: Sucker Movements

Two radio-telemetry projects have studied movement patterns in the Tule Lake sucker population (Hicks et al. 2000; USBR 2000c). These studies indicate that adult suckers use relatively little of the available habitat in Tule Lake, especially Sump 1B which is apparently avoided by suckers owing possibly to shallow depths and poor water quality. Adult suckers were generally located in water depths greater than 0.8 m, representing a very small area of available habitat in Sump 1A. There is also evidence that both sumps have filled in substantially over the last several decades due to sedimentation (Hicks et al. 2000). Nothing is known about habitat usage of Tule Lake and the lower Lost River by other sucker life history stages.

Reclamation conducted radio telemetry studies of adult shortnose and LRS from 1993-1995 at Tule Lake (USBR 2000c). Five adult LRS and five adult SNS were captured in Sump 1A, radio-tagged, and released in April 1993. LRS and SNS movements were similar throughout the study period with both species intermixed. LRS and SNS resided in the English Channel during March and April, then moved along the southwest dike of Sump 1A to an area at the southern end of Sump 1A. This area, called the" Donut Hole", is located approximately one mile northeast of Pump 9 and is approximately 250 acres in size with a mean depth of 3 ft. The suckers remained in the Donut Hole until late October when they began dispersing and concentrating in the northwest corner of Sump 1A. They remained there through the winter. In April 1994 they again moved to the English Channel. Movement patterns in 1994 were similar to1993.

In 1999, the Refuge began a study of sucker habitat use and water quality in Tule Lake sumps as part of a proposed wetland enhancement project (Hicks et al. 2000). This was an extension of earlier radio tracking studies done by Reclamation staff from 1992-1995, described above. Eleven adult LRS and four adult SNS were radio-tagged during April and May. Results of the Refuge study largely agreed with those done previously by Reclamation. In April-May, when fish are most active, they are primarily concentrated in the English Channel, between the sumps, with a scattering of fish located elsewhere in 1A. From June-September, suckers are in the Donut Hole, and in September - February, suckers are in the northwest corner of Sump 1-A.

Very few of the radio-tagged suckers migrated up the Lost River during the spawning season. None of the 10 suckers tagged in 1993 migrated upstream in 1994. In 1999, one of eight LRS tagged in Tule Lake migrated upstream to Anderson Rose Dam. In 2000, two out of 14 suckers migrated.

Radio-tagged LRS and SNS generally remained in Sump 1A throughout both studies (Hicks et al. 2000; USBR 2000c). Their use of Sump 1A may be related to better water quality conditions that generally occurred there compared to Sump 1B. The most important water quality parameters seemed to be pH and DO. Potentially stressful and lethal levels of high pH (>10.0) were much more common in Sump 1B, and Sump 1B had more potentially stressful DO conditions. Both species of suckers concentrated in a small area of 1A during the summer months ("Donut Hole"). Dissolved oxygen and pH values were less variable there than other water quality sampling sites in 1A and 1B. Water quality conditions where radio tagged suckers occurred included temperatures up to 22.5E C, a pH as high as 9.9, and DO as low as 4.7 mg/l (above stressful levels of about 4.0 mg/l or lethal levels of <2.0 mg/l). The "Donut Hole" was unique in that rooted aquatic plant growth was low and the water was frequently quite turbid compared to other sites during the summer. The bottom substrate was firmer and composed of clay and other inorganic sediment particles compared to the softer organic peat substrates found elsewhere.

Tule Lake Sumps: Sucker Population Status

Based on spawning run observations at Anderson Rose Dam and recent sucker monitoring in Tule Lake to capture adults for the radio telemetry studies, it appears that the adult populations of LRS and SNS are larger than those estimated in 1994. Between 1993 and 2000 Reclamation tagged and released 91 LRS and 14 SNS below Anderson Rose Dam. In 1995, two of 9 LRS that were tagged in 1993 were recaptured. In 1999, one out of 17 LRS captured was a recapture from 1993 and in 2000 seven LRS were previously tagged fish (40 captured). It appears that there may be several hundred adults of both species present.

The above studies suggest that sucker populations residing in what remains of Tule Lake are very likely limited by a lack of recruitment, inadequate water depth, and seasonally poor water quality. At first examination, the small size of the sucker population in Tule lake would suggest that they are of little significance. However, this population is healthy, being free of parasites and skin infections, and has a higher condition factor than suckers found elsewhere in the Basin (Scoppettone, Shea, and Buettner 1995). Furthermore, if significant sucker die-offs in UKL continue, sucker populations elsewhere, including Tule Lake, will become crucial to the long-term survival of these species (Perkins et al. 2000a). Other than Clear Lake and UKL, Tule Lake is the only other site that contains a significant population of both LRS and SNS; Gerber Reservoir does not contain LRS. If water quality, depth, and spawning requirements of suckers can be met, the Tule Lake populations could perhaps make an important contribution towards the recovery of the LRS and SNS.

Upper Klamath Lake

Historical Conditions

UKL (including Agency Lake), with a surface area ranging from 60,000 to 90,000 acres depending on lake levels, is currently the largest water body in the Klamath basin. Historically the lake had a surface area of about 105,000 acres (Rosborough 1917, cited by Gearheart et al. 1995). Mean

summer depth is now about seven feet. Hydraulic residence time is approximately 0.5 years. Its waters are generally well mixed because of shallowness. The major water sources for UKL are the Williamson/Sprague (46% of total inflow) and Wood (15%) rivers, and various large springs (17%) which provide about 78% of the annual inflow (Miller and Tash 1967). Regulation of water levels in UKL began in 1919, with completion of the Link River Dam. By 1921 the reef at the entrance to Link River was lowered. Prior to construction of the dam, the lake level varied from about 4139.9 to 4143.1 ft., with a mean annual variation of about two ft (USBR data). However, the range may have been even greater, from 4139.9 to 4145 ft (USBR 2000b). Since 1921, water levels have varied from 4136.8 to 4143.3 ft., a range of about 6.5 ft (USBR data). Water level regulation has also changed the seasonal timing of high and low elevation by making the highest and lowest elevations occur earlier in the season as well as prolonging the period of low water. This has had profound effects on the ecology of the lake, as described below.

Upper Klamath Lake Sub-basin: Wetland Ecology

Wetlands play a crucial part in the ecology of UKL today; however, in the past, prior to widespread wetland loss and degradation, they were even more significant. The total number of acres of wetlands affecting UKL is unknown but may have totaled over 150,000 acres when upstream (i.e., Sycan Marsh (about 24,000 acres) and Klamath Marsh (about 35,000 acres), those along the Sprague and Wood rivers, and fringing wetlands and seasonally wet meadows) areas are included (Akins 1970). The largest existing marsh fringing the lake is Upper Klamath Marsh, a National Wildlife Refuge. It was once part of a 60,000 acre wetland/wet-meadow complex extending up the Wood River basin. These wetlands played a critical role in macro-nutrient dynamics, especially phosphorous, and in cycling of particulate and dissolved organics. Likely these wetlands would have been a net sink for phosphorus and nitrogen, and a source for organics. A number of authors have pointed out (e.g., Phinney et al. 1959; Gearheart et al. 1995), the role collodial humic substances, originating from wetlands, may have had on regulating primary production. Although not fully understood, it appears that humics in association with low pH, can reduce *AFA* blooms, and might have been one factor responsible for the absence or near absence of *AFA* until the last century.

Historically shallow-water (littoral) wetlands fringing UKL have been drastically reduced in size due to agricultural reclamation. Approximately 35,000 acres were diked and drained in UKL in the 20th Century (Gearheart et al. 1995). Although about 15,000 of these acres are in the process of being restored, they have subsided so much that they would be deep water habitat if reconnected to the lake. All major lake tributaries have been altered to varying degree by diking, channelization, and are influenced by agricultural and forestry runoff, and nutrient input from small urban areas such as Chiloquin.

Upper Klamath Lake: Aquatic Biota

UKL has been highly productive for some time owing to the abundance of micro-algae and cyanobacteria. Eilers et al. (2000) studied the paleolimnology of UKL and found evidence that it has likely been highly productive for at least 1000 years. The species composition of algae and

cyanobacteria found in sediment cores suggest a system characteristic of high nutrient conditions for the 1000 year period of record, but that a major change occurred in the last century. *AFA* resting stages (akinetes) first appeared in sediment cores at depths, about 20 cm, determined to represent sedimentation in the 20th Century, and akinete numbers increased steadily (Bradbury and Coleman, USGS 1991, unpub. data; Eilers et al. 2000, 2001). *AFA* is now the dominant primary producer in UKL. The authors concluded that the appearance of *AFA* and switch in dominance was likely associated with a relative increase in phosphorus loading which benefitted *AFA* to an extent that it became dominant.

AFA predominance is indicative of a change in trophic status of UKL from eutrophic to hypereutrophic. Under current conditions, *AFA* bloom conditions reach concentrations of 30,000 filaments per liter (Johnson et al. 1985). *AFA* is able to fix atmospheric nitrogen, thus it is not fully dependent on available nitrogen concentrations in the water like algae and most other cyanobacteria (Reynolds 1986). As discussed later, *AFA* is able to increase phosphorous internal loading by producing conditions that cause release of phosphorus from lake sediments, and thereby promoting its own growth.

There are at least 16 native species of fishes in the Upper Klamath Basin, most occur in UKL; about 10 additional exotic species have also become establishes in UKL (Logan and Markle 1993; S. Reid, USFWS, pers. comm. 2001). Chubs, especially the endemic blue chub, and exotic fathead minnows are numerically dominant (Simon et al. 2000b). Four species of suckers are present. The LRS, SNS, and Klamath largescale sucker (*Catostomous snyderi*) are the principal suckers in the upper Basin. However, a single Klamath smallscale sucker (*Catostomous rimiculus*) has been identified from UKL during recent genetic studies (Tranah and May 1998, 1999; Wagman and Markle 2000).

Hazel (1969) found that the UKL benthos was dominated by oligochaete worms, leeches, and chironomids; maximum mean densities of chironimids reached about 2,000/square meter. Kann (1997) found that the cladocerns dominate the zooplankon biomass in UKL and can exceed densities of 100/l, although mean densities are much lower. Kann believed that cladocerns selectively grazed on smaller phytoplankon species in summer promoting the growth of *AFA*. The abundance of cladocerans in the lake has stimulated recent interest in their harvest as a food source for mariculture (Gutermuth, Cell Tech, pers. comm. 1999). Parker et al. (2000) speculated that hypereutrophic conditions in UKL might reduce the availability of cladoceran and chironomid prey for suckers; however, available data seems to suggest that densities of chironomids or cladocerns are high and are not likely to be limiting. More discussion on UKL ecology is provided below.

Upper Klamath Lake: Adult Sucker Population Estimates

Monitoring the population status of SNS and LRS in UKL and its tributaries has received considerable attention. Although the available population estimates provide perspective on population size, the high variability of the system, sampling constraints, and inherent, though unavoidable, weaknesses of sampling methodology have made it extremely difficult to obtain accurate population estimates. Accordingly, they should be used with extreme caution.

The first attempt to assess the status of sucker populations in UKL was done by Bond et al. (cited in Andreasen 1975). They found that suckers represented only 1% of the fish caught. Andreasen (1975) discussed the change in numbers of suckers spawning in the Sprague and lower Williamson rivers based on creel surveys conducted from 1966 to 1974. Numbers of fish harvested increased from 1.2 fish per hour in 1966 to 4.7 fish/h in 1969; thereafter there was a steady decline to 0.8 fish/h in 1974. Golden (1969) reported that more than 3,000 suckers were taken in the snag fishery in 1968. Reclamation has funded recent monitoring efforts by USGS, Biological Resource Division and OSU (Markle et al. 2000a; NBS 1996; Perkins et al. 1997; Perkins et al. unpub. data).

Reclamation funded efforts by USGS, Biological Resource Division to provide population estimates based on fish tagging efforts in the Williamson/Sprague spawning runs and recovery of tags from the fish kills in 1995-97 (NBS 1996; Perkins et al. 1997; USGS unpub. data). The population estimate data derived from fish kills should be used with considerable caution for a number of reasons, including: (1) very low number of tags were actually recovered and included in calculations, resulting in extremely broad confidence intervals; (2) many of the suckers collected from the die-offs were in a highly decomposed state; some may have lost their tags, and sampling was difficult; (3) the die-off fish may represent a biased group of fish, with relatively few from the Williamson River spawning group; (4) the die-off may have been selective for age/size classes not well represented in the Williamson River where most of the tagging occurred; (5) the estimates are based on an assumption of no recruitment into the adult population during the intervening time; (6) the estimates are based on an assumption that all adults participated in the spawning run each year, even after the stressful environmental conditions of the study period; 7) the estimates used a statistical method that is not robust when
basic assumptions are violated, which almost certainly occurred (see below); and 8) the estimates are for the populations prior to the fish kills.

In the spring of 1995, USGS tagged 60 LRS and 405 SNS in the lower Williamson River. Later in 1995 a relatively large sucker die-off occurred and many fish were collected and checked for tags. Approximately 300 LRS and 100 SNS were checked for tags. No tags were detected, and it was not possible to estimate population size. In 1996, 307 LRS and 1080 SNS were tagged and included in calculations. 1,572 LRS and 1,494 SNS adults were collected from a 1996 fish kill and examined for tags. 3 LRS and 10 SNS had tags. All three LRS and six of the SNS had been tagged in the Williamson or Sprague Rivers in spring 1996. These fish were used to estimate population sizes prior to the fish kill. The four additional tagged SNS had been tagged in previous years and were not appropriate for inclusion in the calculation of the population estimates. In 1996, the LRS population prior to the fish kill was estimated at 94,000 (+/- 82,000; 95% confidence interval) and the SNS population was estimated at 250,000 (+/-175,000 95% CI), respectively (USGS, unpub. data). In 1997, 269 LRS and 1,318 SNS were tagged and included in calculations. 511 LRS and 993 SNS were collected from a 1997 fish kill and examined for tags. Two LRS and 8 SNS had tags. In 1997, the LRS population prior to the fish kill was estimated at 46,000 (+/-45,000 95% CI) and the SNS population was estimated at 146,000 (+/-90,000, 95% CI).

The USGS population estimates utilized the Lincoln-Petersen method to estimate abundance, which

is not statistically robust under violations of its assumptions (Shively, BRD pers. comm. 2001). Two primary assumptions of this method are that (1) marked fish have mixed randomly in the population, and (2) all fish had an equal chance of being marked. A violation of at least one of these assumptions likely occurred with the 1997 estimate. Fifty percent of tagged fish recaptured from the 1997 fish kill were collected on one date (9/5/1997), indicating that fish were highly unlikely to have mixed randomly into the Summer UKL population. The second assumption, that all fish in the fish kill sample had an equal opportunity to be marked, was also not met, since the UKL sucker populations contain spawning groups that utilize various sites besides the Williamson/Sprague rivers (where the tagging was done) and possibly other groups that had not made a spawning run that year.

The USGS estimates are also sensitive to size biases in the sampling and possibly fish kill mortality patterns. Perkins et al. (1996) provided estimates for shortnose suckers computed two different ways, with and without adjustment for size selectivity of fish recovered during the fish kill. The resulting estimates for SNS show the considerable difference in methods: N = 229,588 (+/- 158,207 95% CI) with no adjustment vs. N = 107,653 (+/- 73,795 95% CI) with adjustments. For this comparison, Perkins used a different method (Chapman 1951, cited in Perkins et al. 1996) than is reported in preceding paragraphs. The broad confidence intervals and uncertainties associated with these data make absolute population estimates and inter-annual comparisons inappropriate.

Upper Klamath Lake: Larval and Juvenile Sucker Abundance

Simon et al. (2000a,b) have monitored the status of larval suckers in UKL since 1995. Since 1995, larval trawl catch rates have been substantial every year except 1998 (Simon et al. 2000b). Mean larval trawl catch rates in 1999 were higher than any year since 1995. The proportion of positive catches (catches >0) was 51, 53, 44, 36, and 43% for 1995-1999 respectively. The proportion of large catches (>100 fish) ranged from 0.0-7.1%, with the two highest percentages in 1996 and 1999, and the two lowest in 1997 -1998. Although one larval survey effort resulted in high catch rates in 1997, it did not persist as catches dropped by the next survey and combined catches with all gears were low throughout the year. High levels of un-ionized ammonia that year may have inflicted high mortality on larvae (Simon et al. 1998). There was no correlation among adult spawning run indices (Markle et al. 2000a) and larval indices from 1995-1999.

Simon et al. (2000 b) monitored the status of juvenile suckers in UKL since 1991 and reported that annual abundance (based on CPUE of beach seines) for age 0+ suckers at the end of summer were relatively high in 1991, 1993, 1995, 1996 and 1999, but were very low in the drought years of 1992 and 1994, and in 1997 and 1998 during and following the fish kills. The relatively low abundance of age 0 suckers in UKL in 1998 has been questioned by Gutermuth et al. (1999) who found large numbers of juvenile suckers in entrainment studies at the Link River canals. This discrepancy has not been resolved. Gutermuth et al. (1999) also found more sucker larvae entrained in the canals in 1998 than in 1997. Simon et al (2000b) found that age 0 sucker numbers were up in 1999, with mean catches from beach seines, cast nets, and otter trawls, being the highest of any year from 1995-1998. There was little correlation (r = 0.22) among adult spawning run indices and beach seine indices from 1995-1999, but there was a much stronger correlation (r

= 0.77) between larval trawl and beach seine indices.

Simon et al. (2000a) found that age 0 LRS peaked in 1995 with an estimated late summer/early fall abundance index of 35,000; however, this value was exceeded in 1999 with an estimate of >80,000 (Simon et al. 2000b). Simon et al. (2000a) considered that age 0 SNS had peaked in 1996 at 16,000, but 1999 data showed an even larger estimate of >80,000 (Simon et al. (2000b). As in previous years, there was almost an order of magnitude decrease in age 0 sucker abundance during summer and fall. The exact cause of this decline is unknown but predation, water quality, and especially entrainment losses are potential factors.

Based on shoreline cast net surveys, the mean shoreline abundance index for LRS was higher in 1999 than 1995-1997, but similar to 1998, while the mean shoreline abundance index for SNS was higher in 1999 than 1997 but similar to 1995, 1996, and 1998 (Simon et al. 2000b). Other indices suggest near-shore abundance was highest in 1999 compared to previous years. The proportion of positive catches (>0), and the proportion of large catches (>5 and >10) were all higher in 1999 than 1995-1998. In 1999, 43% of suckers captured were LRS and 57% SNS.

Otter trawl catches in late summer/fall were much higher in 1999 than any other year. The total number of age 0 suckers captured during this survey (186) exceeded the total of 60 age 0 suckers captured in all random trawl surveys from 1995-1998. Of these 60, 37 were caught in 1995 and only 23 from 1996-1998. Of the186 age 0 suckers caught otter trawling 156 (84%) were LRS and 30 (16%) were SNS.

The mean whole-lake abundance index for age 0 LRS in 1999 (300,000) was the highest since 1995. The mean whole-lake abundance index for age 0 SNS in 1999 was also the highest, but only slightly higher than 1995, 1996, and 1998. These estimates, along with larval trawl, and beach seine data, suggest that age 0 suckers in 1999 were substantially more abundant than in 1997 or 1998, and were at least or more abundant than 1995-1996. Caution should be used in interpreting the 1998 cast net data as these numbers are probably inflated from a single sample in which an inordinately large number (1168) of suckers were caught. Without this sample, cast net abundance data are similar to 1997. Larval trawl and beach seine data from 1998 are also similar to that of 1997, and suggest that these two years probably represent poor recruitment. The data suggests 1999 was a good year for juvenile sucker recruitment.

During the period 1995-1998, larval and juvenile sucker abundance generally declined (Simon et al. 2000b). During this same period, adult spawning run indices of both LRS and SNS also declined (Markle et al. 2000a). Adult spawning run indices continued to decline in 1999 (Markle et al. 2000a), however, larval and juvenile numbers reversed their declining trends and were abundant in 1999, suggesting a poor stock-recruitment relationship, i.e., there is a poor correlation between adult spawning population and young fish produced. This likely indicates that environmental factors are controlling recruitment.

In all years, age 0 Lost River and SNS abundance indices in September and October were less than August. This consistent annual trend of sharply decreasing age 0 sucker numbers in late summer and fall remains a concern. It is suspected that this can be partially explained by a shift in

habitat from shoreline to offshore areas (Simon et al. 1996), but it also may be due to downstream movement of young suckers, or high mortality rates, or a combination of these factors.

Simon et al. (2000a,b) found that spring catch rates of age 1+ suckers in UKL for all years were relatively low. For example in the spring of 1999, no age 1+ suckers were collected in otter trawls. This trend is disturbing and may suggest that little or no recruitment has occurred since 1991 even though larval and juvenile numbers appeared substantial in summer and fall samples. However, the otter trawl is not effective at catching larger fish, and thus this trend could be explained by sampling bias. Recruitment is perhaps better determined by a regular examination of age-class frequency.

Upper Klamath Lake: Distribution of Juvenile Suckers

Spatial and temporal distribution of juvenile suckers in UKL has been studied through an intensive systematic monitoring program during the summer and fall from 1995-1999 (Simon et al. 2000b). Juvenile suckers were collected from throughout UKL at fixed sites using beach seines and from stratified randomly selected sites using cast nets and otter trawls. Stratified random cast net sampling showed three major areas of age 0 sucker concentration in UKL in 1997; the south end of the lake, an area primarily south of Buck Island; the eastern shoreline from Modoc Point to Hagelstein Park; and the Shoalwater Bay/Ball Bay region (Simon et al. 2000b). Consistently high beach seine catch rates of juveniles were documented for the mouth of the Williamson River, Goose Bay, and Modoc Point for most years. High densities were noted at Howard Bay (1996) and Hagelstein Park and Stone House (1999). Beach seine catches were very low in Agency Lake and most stations on the west side of UKL. Catches at these locations were primarily of SNS.

Gutermuth et al. (1999) has found relatively large numbers of juvenile suckers in Link River diversion canals, and Reclamation biologists have also salvaged considerable numbers of suckers in canals leading from the A-Canal at the Link River. Gutermuth et al. (2000) suggested that large numbers of juvenile suckers in the lower parts of UKL might be the result of dispersal behavior. Available information indicates that large numbers of young suckers are leaving UKL via diversions and down Link River. Considering that most of the suckers and other fish entrained into these diversions will die owing to water quality problems, lack of food, predators, being drawn into pumps, etc., and that there is little suitable habitat downstream of UKL, these losses retard recovery.

Upper Klamath Lake: Adult Sucker Age Structure

In the 1980's, LRS spawning runs in the Williamson and Sprague Rivers were dominated by large and presumably older fish (Buettner and Scoppettone 1990). Aging data collected from a lake die-off in 1986, indicated that most fish were 19-28 years old. Twenty-six year classes were documented with fish ranging from 8 to 43 years old. In 1988, 33 LRS were aged from spawning runs up the Sprague and Williamson rivers. These fish ranged from 9-30 years old with the majority between10 and 11 years.

SNS spawning runs in the 1980's in the Williamson and Sprague Rivers were numerically small

(Buettner and Scoppettone 1990). Length frequency and ageing data was not nearly as extensive as for LRS. Only 18 SNS were aged from 1986 to 1988. They ranged from 4 to 25 years and represented 12 year-classes. SNS size distributions from 1989 to 1994 were similar to those from the 1980's with most fish ranging from 37-50 cm FL (USGS 1996). Size distribution of the 1995 and 1996 SNS runs in the Sprague and Williamson Rivers were mostly 30-40 cm FL.

The Klamath Tribes captured small numbers of suckers from the Sprague and Williamson Rivers from 1989 through 1996 for hatchery propagation and other research purposes. Size distribution of these captures were presented by USGS (1996). Although the sample sizes were small, LRS distributions were similar from 1989 to 1994 with mostly larger fish (50-75 cm FL). Size distribution of the 1995 and 1996 LRS spawning runs in the Williamson and Sprague Rivers were shifted downward; most fish were 40-50 cm FL.

The shift in size distribution appeared to be related to recent recruitment to the adult population combined with a disappearance of older year classes. Age distribution information is based mostly on fish die-off events during 1995 (USBR 1996c), 1996 (USGS 1996) and 1997 (USGS, Unpub. data). Ninety-five percent of the suckers were age 7 years or younger with most age 4 (1991 year-class) and 5 (1990 year-class). Only age 14 and 9 year-classes were documented for LRS and SNS respectively.

Examination of about 860 suckers from the 1996 fish kill documented LRS and SNS that were mostly 2-8 years old (USGS, unpub. data). Eighteen year-classes of LRS and 11 year-classes of SNS were identified. The most abundant year-class of both species was 1991; the 1988, 1989, 1990, 1992 and 1993 year classes were also fairly well represented. In 1997, older LRS and SNS were dominant in the die-off, with 28 and 20 year-classes represented respectively.

Summary of Sucker Status in UKL

It is unclear what annual LRS and SNS population sizes are in UKL. However, trends are apparent, although the available information should be used with extreme caution when drawing conclusions about annual changes in populations size. The available data are generally not statistically robust and therefore of limited use for inter-annual comparisons. This is because catches are biased by many factors, especially sampling biases, timing and sensitivity of to weather and water conditions that may vary spatially and temporally. Also, fish are patchily distributed in space and time, with many individual collections yielding low numbers of fish or none. Estimates of means based on these kinds of samples have broad confidence intervals and therefore may not be accurate.

In the mid-1980s large, old fish dominated spawning populations. However, over the next 13 years there was only a single strong year class produced and that was in 1991 (Perkins et al. 2000). At the time of listing in 1988, populations of SNS and LRS in UKL were considered very low relative to former population sizes (USFWS 1993a). This conclusion was based on a number of factors, but no accurate population estimate was available. By 1995, there was an increase in the numbers of spawning adults in the Williamson and Sprague rivers due to recruitment of the strong 1991 year class (Perkins et al. 2000). However, fish kills in 1995, 1996 and 1997 apparently had

a substantial negative effect on sucker population sizes and age class distributions. From 1995 to 1997 there was a substantial decline in the number of adults making spawning runs in the Williamson River, that amounted to an estimated 80-90% reduction in the adult population size for both LRS and SNS (Perkins et al. 2000). Markle et al. (2000) found evidence that numbers of suckers in the Williamson River spawning migration in 1999 were still apparently depressed by loss of adults in 1995-1997 fish kills. However, for the 2000 spawning run, Cunningham and Shively (2001) found slightly higher abundance index values for LRS and SNS in the lower Williamson River than for the previous 3 years and an improved size-class distribution, indicative of possible improving population status.

Loss of several spawning stocks is an additional indication of declining sucker populations. Historical spawning areas that no longer support runs include: Odessa Creek, Fourmile Creek, Harriman Springs, Barkley Springs, Crooked Creek, Fort Creek, and Sevenmile Creek. Oregon State University also identified several shoreline springs along the east side of UKL that probably once supported spawning groups that apparently are not presently being used (OSU, unpub. data). Hatchery personnel apparently observed spawning runs of suckers several times in Crooked Creek as late as 1987 (Roger Smith, ODFW pers.comm. 2001). However, the current status of the runs is not known. There is no documented evidence of current sucker spawning runs in the other streams.

Upper Klamath Lake: Tributary Spawning

In the UKL sub-basin, LRS spawning runs are primarily limited to the lower Sprague and Williamson rivers, but small runs also occur in Wood River and Crooked Creek (Markle and Simon 1993). In 1996, a small spawning run of SNS was documented in the Wood River (USBR, unpub. data) but no samples were taken.

Chiloquin Dam Fish Ladder

The Chiloquin Dam built on the Sprague River in 1927 has fish passage facilities. Studies in the 1970s and 80s suggested that SNS and LRS did not use the ladders to any significant extent and that Klamath largescale were the principle sucker using the ladder (Bienz and Ziller 1987). These authors suggested that good SNS spawning habitat might be available in the Sprague River above the dam. Buettner and Scoppettone (1990) suggested that sucker spawning runs in the Sprague River above Chiloquin Dam have been depressed for many years due in part to poorly designed and maintained passage facilities at the dam. The Sprague River likely supported large spawning runs of suckers historically.

In 1995 and 1996, a few mature LRS were captured during late March at Kirk Springs, about 65 miles above UKL in the Sprague River (Dunsmoor, Klamath Tribes, pers. comm. 1999). This is the first recent verification that LRS negotiate the Chiloquin Dam fish ladder and migrate long distances upstream to spawn.

The Klamath Tribes have monitored sucker spawning runs at the Chiloquin Dam fish ladder intermittently since the early 1980's (Bienz and Ziller 1987; Klamath Tribes, Unpub. data). In 1996, the Tribes monitored the ladder on 17 dates between February 15 and May 30. During

sampling, the ladder was blocked off and water levels lowered to allow for sampling of all cells with dipnets. One-hundred-fifty-seven SNS were captured from May 8 to May 30 including 72 females and 85 males. SNS spawners ranged from 32 to 47 cm FL (mean 37 cm FL); SNS males averaged 35 cm FL and females 40 cm FL.

Two LRS were captured March 20 and one on March 21. This species was not captured again until May 8. From this date until May 30 substantial numbers were captured each day sampled. Sampling was discontinued at the end of May because most fish captured were spawned out fish migrating downstream. Eighty-two females and 57 males were captured. They ranged from 26 cm FL to 56 cm FL, with a mean length of both sexes of 45 cm FL. Upstream movements of both LRS and SNS appeared to peak the first two weeks of May and they moved back downstream in late May to early June.

Most Sprague River LRS sampled ranged from 40-50 cm FL, similar to the length distribution from trammel netting at the mouth of the Williamson River (USGS 1996). Adults greater than 56 cm were not captured in the fish ladder at the Chiloquin Dam although 8% of the fish captured in the lower Williamson River were in this size range. This is consistent with observations in the 1980's when large LRS were common below the dam, but rare or absent in the ladder (Coleman et al. 1988). The lack of large LRS in the ladder could be due to the inability to ascend the ladder, a general aversion to the ladder, or a preference for spawning in areas downstream of the ladder. Minimal differences in size distribution existed between SNS captured in the fish ladder and those captured in the Williamson River (NBS 1996).

The Chiloquin Dam fish ladder was monitored on 34 dates in 2000 (Shivley et al. 2001). Between March 8 and June 7 over 1,400 suckers were captured. They consisted predominately of LRS (46%) and possible LRS x KLS "hybrids" (31%). There appeared to be at least two distinct peaks of suckers moving through the ladder. The early peak during the latter half of March consisted mainly of KLS and a group that displayed intermediate characteristics between KLS and LRS. The second peak of fish in April consisted mostly of LRS with some SNS. Catches dropped to near zero after May 4. Catches of LRS, KLS, and potential "hybrids" appeared to be correlated with air temperature. About 5% of the suckers captured were recaptures. Most of these (81%) were originally tagged at the ladder, suggesting that like the lakeshore spawning fish, those spawning in the Sprague River appear to be a distinct population.

A small number of LRS were captured in late March suggesting that there may be a small early run of this species. In the third week of March 1995, LRS were observed spawning at Kirk Spring in the upper Sprague River (Larry Dunsmoor, Klamath Tribes, pers. comm.). LRS ranged from 35-68 cm FL with a mean of 53 cm FL (n = 549). SNS ranged from 30-53cm FL with a mean of approximately 40 cm FL (n = 103).

Sixty-five fish were captured that had been tagged in previous years sampling. The majority of these fish were originally tagged at the Chiloquin Dam fish ladder. Most of the recaptured fish were KLS or KLS-like fish. Only three LRS and one SNS were previously tagged. Given the large number of LRS (n = 647) and the low percentage of recaptured fish, we believe this run of LRS has been relatively unsampled in the past.

Lower Williamson River: Adult Sucker Population Monitoring

From 1995 to 2000, USGS and OSU monitored adult suckers near the mouth of the Williamson River as they migrated upstream to spawn (Perkins et al. 2000a; Markle et al. 2000a; Cunningham and Shively 2001). Inter-annual comparisons should, however, be interpreted with caution due to a number of variables and sampling differences between years

Sampling in different years started on dates ranging from mid-February (1998) to mid-April (1999). Stop dates also differed, being as early as late May in 1998 and as late as early August (1999). During two sampling years, 1995 and 1999, catches on the first sampling date were high, suggesting underestimation of early spawners. Time of day may also have affected sampling results. In 1997 and 1998, diel studies indicated that the migration of suckers in the lower Williamson River were several times higher in early morning (0500-0730 h) and evening (1800-2200 h) than other times of the day (Perkins et al. 2000a). In 1999, Markle et al. (2000a) documented a similar pattern of high early morning catch rates. In 2000, USGS sampled from early morning (0500-0600 h) until 10-12 (noon). No evening sampling was conducted in 1999 or 2000. The timing of sucker movements may also depend on cues other than time of day. Perkins et al. (2000a) noted that temperature appeared to cue migrations with peak movements occurring at 10-15 C. Markle et al. (2000a) found similar temperature ranges during migrations in 1999. Changes in weather patterns and the arrival of cold fronts appears to reduce fish movements. Highest catch rates occurred during clear, warm weather. Fish distribution was often patchy, with significantly different catch rates among nets 100 m apart.

From 1995 to 1998 river discharge did not seem to have a strong effect on timing of adult sucker catch rates in the lower Williamson River. However, in 1999 adult catches peaked just prior to the peak in the hydrograph. It is likely that trammel net efficiency was reduced at higher discharge rates, underestimating the size of the spawning run during years when flows were higher. Mean April and May discharge rates were similar from 1995-1997, averaging about 2000 cfs per year, yet adult abundance values decreased steadily. Discharge rates increased substantially in 1998 and 1999 (2500-3000 cfs), and adult sucker catches continued to decline. In 2000, discharges were similar to 1995-1997 and catch rates were higher. While this may represent increased recruitment of first time spawners from the 1991 and 1993 year-classes in 2000, it also suggests that higher discharge rates may have contributed to underestimates of run size in 1998 and 1999.

Additional caution should be used in interpretation of the lower Williamson River spawning abundance indices because: (1) LRS and SNS may vary in their vulnerability to capture in trammel nets; (2) only a proportion of each population occurs in the Williamson River in any given year and this proportion probably varies between species and among years; (3) residual use by non-spawning adults will over estimate the population and (4) spawned out fish returning to the lake made up a high percentage of the catch in at least one year (2000). Experience at Clear Lake Reservoir indicates that SNS are about twice as vulnerable as LRS to trammel nets, possibly due to different feeding behaviors. Whether vulnerability varies between the species during the spawning season is unknown. In 1999, substantial residual use in June and July by non-spawning suckers was documented in the lower Williamson River. This use may also occur during the spawning migration period.

Acknowledging the above cautions, the results of the population monitoring are still valuable for providing indications of year to year variability and approximations of relative differences in spawning runs. Adult abundance index values for both sucker species declined continuously over the five-year period from1995-1999, then in 2000 rose to the highest values since 1995 for LRS and since 1997 for SNS (Markle et al. 2000a; Perkins et al. 2000a; Cunningham and Shively 2001). LRS abundance values for the years 1995-2000 were 21, 5, 4, 3, 1, and 10 , respectively (using comparable daytime trammel net sampling data, rounded to units). SNS abundance values for the years 1995-2000 were 175, 100, 22, 9, 9, and 21 , respectively. The increase in population indices seen in 2000 suggest there has been some increase in adult population size since the 1995-1997 die-offs, particularly in LRS (Cunningham and Shively 2001). This was also indicated by the size-class distribution which included more classes than the previous three years (USGS unpub. data).

Status of Williamson/Sprague River Sucker Spawning Populations

The demographics of the Williamson/Sprague River system sucker spawning populations appear to be much different in the late 1990's than during the mid-1980's. In 1984 and 1985, the spawning runs of LRS and SNS in the Williamson and Sprague Rivers were composed primarily of large, presumably old fish, suggesting that both species had experienced an extended period of minimal adult recruitment (Bienz and Ziller 1987). Shifts towards smaller fish of both species in the late 1980's and again in the mid to late 1990's suggest the recruitment of younger year classes. Ageing data from fish collected in the 1995-1997 UKL fish die-offs indicate that the majority of adult suckers were from the 1991 year-class. Recruits from the 1993 year-class may have started to appear in 1998 as indicated by a peak in the size distribution of male SNS (Perkins et al. 2000a). Young-of-year (age 0) assessments indicated relatively high numbers of LRS and SNS were produced in 1991 and 1993 (Simon et al. 2000b).

Cohorts from 1991 and 1993 both correspond to years that had relatively good water quality in the summer relative to other recent years (Wood et al. 1996; Kann 1998). 1991 was a very dry year with relatively low lake levels while 1993 was a wet year with relatively high lake levels. Minimum lake levels in 1991 and 1993 were 4138.2 and 4139.5 ft, respectively. The 1991 year-class also corresponds to a year in which the April discharge of the Williamson River was the second lowest on record (1920-1998), which could have benefitted reproduction by minimizing egg loss (Perkins et al. 2000a).

Size distribution of LRS and SNS captured from the Williamson and Sprague Rivers from 1995-1996 were much different than those documented in the 1980's. Specifically, small LRS (40-50 cm FL) dominated the catch in 1995 and 1996 while larger fish were more abundant in the 1980's (60-70 cm FL) (Bienz and Ziller 1987; NBS 1996). LRS over 60 cm FL were rare in 1995 and 1996. Smaller SNS adults dominated the catch in the Williamson and Sprague rivers in 1995 and 1996 (30-40 cm FL). In 1982-1985, adults 40-50 cm FL were most numerous (Bienz and Ziller 1987).

In 1997 and 1998 there was a shift in the length frequency distribution to larger sizes for both LRS and SNS compared to 1995 and 1996 (Perkins et al. 2000a). Most of the LRS were over 50 cm

FL with a peak in size distribution of about 52 cm FL in 1997 and 54 cm in 1998. In 1999, it was difficult to see any length frequency trend since only 20 LRS were captured (Markle et al. 2000a). In 2000, most LRS ranged from 48-60 cm FL with a peak in distribution at about 53 cm FL. There were fewer fish in the 40-50 cm FL range and >60 cm FL than 1995-1998 (Cunningham and Shively 2001).

The SNS peak size distribution increased from about 32 cm FL in 1995, to 36 cm FL in 1996, and 38 cm FL in 1997. The 1998, SNS length frequency distribution was more like 1996. This shift back may have been affected by the 1993 year-class, which may have started to recruit into the adult spawning population, affecting the size distribution. In 1999, smaller SNS (31-35 cm FL) dominated the catch suggesting that the 1993 year-class may have dominated the run. SNS were mostly 33-43 cm FL in 2000, with a peak about 40 cm FL.

Link River: Sucker Status

The Link River historically carried the entire surface outflow from Upper Klamath Lake. The head of the river was formed by a basalt sill, near the entrance to A-canal and about one-third of a mile upstream from the present dam. Water flowed over this sill into a low-energy lacustrine reach and then over a second sill at the present dam site. From this sill the water flowed down relatively high-gradient rapids for about 1.7 miles with a drop of approximately 55 feet to Lake Ewauna. The only natural "falls" in the Link River that potentially blocked fish passage are two small drops of 3-4 ft on either side of a bedrock island about 600 ft downstream of the present dam site (USBR 2000). At flows of 2,500 cfs, or greater, the "falls" are completely inundated. Dynamite apparently was used to clear log jams in the Link River at least once in 1911 (Spindor 1996); however, the exact location and effect on the channel morphology is not known.

Water withdrawals from the upper Link River began in 1868, and in 1878 the Ankeny-Henley canal drew water from near the site of the lower bedrock sill. The A-canal was first opened in 1907, and the westside Keno Canal was completed in 1908. The regulation of water levels in UKL began in 1921, with completion of the Link River Dam and the lowering of the reef at the entrance to Link River. Prior to construction of the dam, the lake level varied from about 4139.9 to 4143.1 ft (USBR data), with a mean annual variation of about 2 ft (USBR data). However, the range may have been even greater from 4140.3 to 4145 ft (USBR 2000b). Since 1921, water levels have varied from 4136.8 to 4143.3 ft., a range of about 6 ft (USBR data). Water level regulation has also changed the seasonal timing of high and low elevation by making the highest and lowest elevations occur earlier in the season as well as prolonging the period of low water.

At present, much of the reduced flow that reaches the Link River after diversions into A-canal is diverted around the upper 2/3 of the river by two hydropower diversions operated by PacifiCorp. The diversions, one on each side of the river, originate at the Link River Dam. The westside diversion has a maximum capacity of 300 cfs; the eastside 1200 cfs. Minimum releases to the river is 100 cfs. The power houses are located about 1/4 mile above Lake Ewauna.

Link River Dam is equipped with an old and apparently ineffective fish ladder on the east side intended to provide upstream passage for salmonids through the Link River to UKL (Ott 1990,

PacifiCorp 1997). The ladder is a pool and weir type which was retrofitted to the dam in 1926. In 1952, a spillway apron and training walls were installed downstream of six stoplog bays, and the stoplogs were replaced by gates. In 1975, the stoplogs in the other bays were joined together to form wooden gates, and a lifting mechanism was installed. A vertical slot entrance pool was added in 1988. It is currently about 105 ft long, gaining 13 ft in elevation, with 11 pools. Flow through the ladder is approximately 15 cfs. The weir exits into Upper Klamath Lake at elevation 4,138.5 ft, and when lake elevations are below 4,138.5 ft, the ladder is impassable.

PacifiCorp conducted a study in 1990 to identify actions that could be implemented to improve fish passage at Link River Dam (Ott Engineers 1990). Deficiencies of the fish ladder were identified by Ott as: an approach through a long channel with little attraction flow, a poor entrance requiring fish to cross a shallow cascade, small pool volume and shallow water in the lower pools, lack of self-regulating flow adjustment, and general disrepair of the weir baffles. Very low numbers of suckers have been recorded from the Link River fish ladder, which appears to be related to operational procedures, inadequate passage facilities, and a low-flow fish barrier located downstream of the dam (Ott Engineers 1990; PacifiCorp 1997).

From 1988 to 1991, a cooperative study was conducted by PacifiCorp and ODFW to evaluate the status and effectiveness of fish passage at the Link River and other Klamath River fish ladders (Hemmingsen et al. 1992; PacificCorp 1997). Sucker data from this study are available from two sources, original data sheets apparently from J. Fortune (ODFW unpub.) and the PacifiCorp (1997) report which summarizes the data; the two sources provide slightly different numbers, but the data sheets provide more specific information.

At Link River (Fortune data), a total of 19 suckers were caught during the study period, including 4 LRS (525-585 mm FL), 3 SNS (410-465 mm), 2 largescale (600-625 mm), 7 Klamath smallscale (395-475 mm) and 3 unidentified juveniles (187-212 mm). Suckers were present in the ladder only in 1989, a high-flow year with releases from Link River Dam reaching 3,900 cfs, and only in the Spring (April 5 to June 7). PacifiCorp (1997) reported a total of 18 suckers, including 4 LRS, 3 SNS, 6 largescale, 3 Klamath smallscale and 2 unidentified juveniles. Adult suckers were also sighted incidentally by PacificCorp at the mouth of the fish ladder in 1996 (Frank Schrier, Pacific Corps, pers. com. cited in USBR 2001), and Reclamation captured two adult suckers from the ladder in June 1998 (USBR 2001).

Prior to construction of the Link River Dam, there were apparently large spawning runs of suckers migrating up the Link River in March, which were described as “immense congregations” of fish weighing two to six pounds (Klamath Republican 1901). The origin of these runs is not recorded; presumably, they came up out of Lower Klamath Lake or the Lake Ewauna/Keno reach, as lentic habitat was not available below Keno prior to construction of J.C. Boyle dam. Suckers apparently occupied the Link River even in summer, as evidenced by accounts of stranded ‘mullet’, when flow to the Link River was cutoff by southerly winds producing a seiche (oscillation of the upper surface) in Upper Klamath Lake that lowered the level at the outlet to below the sill (Spindor 1996).

There has been no concerted effort to survey the Link River itself for fish distribution and seasonal

use patterns. However, the limited information available demonstrates that adult suckers still make an attempt to migrate upstream in the Link River during the Spring, and at least juveniles apparently reside in the river below the dam throughout most of the year. Primarily juvenile suckers are consistently caught during salvage operations conducted at the base of the Link River Dam during maintenance operations and spill termination, which occurs in most seasons except the January-March time period (USBR 2000). In 1995, 12 suckers (17-51 cm FL) were salvaged in April, 138 juveniles (12-23 cm) in May, and a single juvenile in December. In 1996, 132 suckers (10-36 cm FL) were salvaged in May, 19 (11-29 cm) in June, and a single juvenile in July. In 1997, 10 suckers (9-13 cm FL) were salvaged in June, and 68 suckers (9-25 cm) were salvaged in May. After a spill termination in October 1998, no suckers were observed. In 1999, 12 suckers (about 80 mm FL) were salvaged after a spill termination in September, and in October 1999, 18-19 salvage operations were carried out that caught 44 suckers (7-18 cm FL). In 2000, 12 suckers (5-16 cm FL) were salvaged after a spill termination in September.

While suckers appear to occupy habitat throughout the Link River in low numbers, the lower Link River is probably crucial to suckers and other fish, since it may be the best habitat now available in the reach upstream of Keno. The lower Link River probably serves as a critical refuge for fish during periods of low DO. Water quality in Lake Ewauna is frequently very poor and the higher quality of water in the Link River may allow fish from the lake to survive. Link River, because of its high gradient and numerous cascades, has a significant potential for oxygenation of water prior to entry into Lake Ewauna where there is a high biochemical oxygen demand. Furthermore, a number of small springs along and in the channel add fresh, high-quality water to the river. The Link River also supports a number of endemic mollusk species of concern to the Service (Frest 1998). For many of these mollusks, the Link River and the portion of Lake Ewauna within the influence of Link River contain the largest, or only, populations known. In summer when most of the flow is diverted into the hydroproject, water quality in the Link River itself and the reach's potential to oxygenate water entering Lake Ewauna is greatly compromised by the reduced flow caused by the diversions.

Lake Ewauna and Upper Klamath River above Keno Dam (the Keno Impoundment)

Historically, Lake Ewauna and the upper Klamath River were connected to both the Lost River, at least in years of high water, and to Lower Klamath Lake. In 1890, the paddle-wheeler "Mayflower" was able to navigate up the Lost River Slough and moved down the Lost River to near Merrill. The Lost River Slough was located near the current location of the Lost River Diversion Canal. Steamboats also moved through the Klamath Straits (now Klamath Straits Drain) between the river and Lower Klamath Lake. The Lake Ewauna/ upper Klamath River reach may have formed a critical connectivity corridor for suckers moving between the Upper and Lower Klamath Lakes and the Lost River.

Currently, Lake Ewauna and the upper reach of the Klamath River above the Keno Dam form an impoundment 20 miles-long by 300 to 2600 ft-wide (the Keno Impoundment); depths range from 9 to 20 ft (CH2M Hill 1995). Water surface elevations in this reach are controlled by Keno Dam within 4083 to 4086 ft (USBR datum) to provide sufficient head for irrigation diversions, including the Lost River Diversion Canal and Ady Canal. Water quality in this reach is seasonally

poor owing to UKL outflow, a high sediment biochemical oxygen demand (BOD), and a number of significant discharges with BOD (CH2M Hill 1995; ODEQ 1998). This reach also receives discharges from Klamath Falls and South Suburban sewage treatment plants, Columbia Plywood and Collins Products. In addition, irrigation return flows enter from the Lost River Diversion and the Klamath Straits Drain. In the 1960's there were six sawmills using this reach for log storage. At peak storage, 85 million-board ft of logs covered 400+ acres, consequently there is a considerable amount of bark and wood debris on the bottom (Oregon State Sanitary Authority 1964). Columbia Plywood is the last operating mill in this reach still using in-water log storage. This reach of the Klamath River is 303(d)-listed by Oregon Department of Water Quality (ODEQ) for the following water quality criteria: DO, pH, Chl-a, and ammonia. Sediment DO demands are extreme owing to high levels of organics in the sediments and water column.

Very little is known about the present use of the Keno to Link River reach by suckers or other fishes, and apparently no systematic sampling has been done to date. Hummel (1993) ran 42 trap net sets at various locations throughout the Keno/Lake Ewauna reach in June-July 1993, catching six SNS (21-32 cm FL) at sites dispersed from the Keno bridge to Lake Ewauna. Hummel also reported three suckers (unspecified size or species) trap netted at the Klamath Wildlife Area in an earlier day of trap netting. In 1996, ODFW carried out two days of sampling (May 15 and August 29) in the Lake Ewauna/Keno reach during which they apparently caught a single Lost River sucker of unspecified size (ODFW 1996).

There is evidence that suckers migrate upstream past the Keno Dam. From 1988 to 1991, a cooperative study was conducted by PacifiCorp and ODFW to evaluate the status and effectiveness of fish passage at this and other fish ladders (Hemmingsen et al. 1992; PacifiCorp 1997). Sucker data from this study are available from two sources, original data sheets apparently from J. Fortune (ODFW undated) and the PacifiCorp (1997) report which summarizes the data; the two sources provide slightly different numbers, but the data sheets provide more specific information. At Keno (Fortune data), a total of 141 suckers were caught during the study period, including 8 adult LRS (48-61 cm FL), 4 SNS (22-42 cm FL), 103 KLS (29-51 cm FL), 5 unidentified suckers (19-42 cm FL), 21 unidentified juveniles (no lengths), and apparently no KLS were identified. The LRS were all caught in May-June 1988-89. The SNS were caught in April, July and September of 1990-91. Klamath smallscale sucker (KSS), *Catostomus rimiculus,* were caught August-October 1988 (13: 29-51 cm FL), April-June 1989 (71: 31-51 cm FL) with just two on October 12, April 1990 (6: 37-44 cm FL) or August-October 1990 (9: 40-48 cm), and September 1991 (2: 41 cm FL). Unidentified suckers were caught in April 1990 and September 1991 (5: 19-42 cm FL). Unidentified suckers recorded as juveniles with no lengths were caught in August - September 1989 (6), August 1990 (5), and late July-September 1991 (10). PacifiCorp (1997) reports a total of "130 suckers", including 6 adult LRS, 3 SNS, 6 KLS, 99 KSS, and 22 unidentified juveniles (note incorrect addition).

The capture of adult suckers in the lentic Keno/Lake Ewauna reach, the presence of suckers both in the Link River itself and at both the Link River and Keno fish ladders, and the apparent outmigration of tens of thousands of juveniles from UKL in the late summer and fall (see Entrainment) suggests that the improvement of habitat quality in the Keno/Lake Ewauna reach, coupled with adequate fish passage at the Link River and Keno Dams, would be a key to recovery

of the suckers.

Lower Klamath Lake

Prior to 1917, Lower Klamath Lake was seasonally connected to the Klamath River either when it flooded in Spring or later in the summer when the river level was down and water flowed from the lake to the river (Weddell 2000). Steamboats were even able to navigate the slough that connected the lake and river. The railroad completely severed that connection by 1917, and by 1924, the majority of the Lower Klamath wetlands had been drained (Weddell et al. 1998; Weddell 2000). Connectivity between Lower Klamath Lake and the rest of the Klamath Basin is now limited to water pumped through the ridge from Tule Lake and various irrigation channels that connect into the Keno impoundment, primarily the Klamath Straits Drain and Ady Canal.

Prior to about 1924, suckers migrated up Sheepy Creek (a western spring-fed tributary to Lower Klamath Lake) in sufficient numbers that they were taken for food or to feed hogs (Coots 1965). In 1960, small numbers of large suckers were still observed moving up Sheepy Creek in the springtime (Coots 1965). The available survey information from Lower Klamath Lake or its tributaries since 1960 is very limited. California Department of Fish and Game records show no recent surveys for Sheepy Creek (D. Maria CDFG, pers. comm. 2001). Koch and Contreras (1973) sampled two sites on Sheepy Creek and three on the Klamath Straits Drain, they caught no suckers. However, conditions were difficult on Sheepy Creek and apparently did not allow for effective sampling.

Although irrigation diversions near the mouth of Sheepy Creek apparently block passage upstream (Buettner and Scoppettone 1991), and the creek is substantially reduced by irrigation demands during the summer, most of the creek lies on private land and has not been sampled. Buettner and Scoppettone (1991) did limited single night gill net sets in the Lower Klamath Lake system (June 28-29 1990), including Lower Klamath Lake - Unit 1 and 2 (2 sites), Sheepy Lake (3), Klamath Straits Drain (1), and Ady Canal (1). They caught no suckers, although Buettner (pers. comm. 1999) suggested that suckers might occasionally reach the Lower Klamath Lake sub-basin from the Klamath River via the Ady Canal. An adult sucker was caught near the mouth of Ady canal during sampling for a pelican contaminant study around 1980 (J. Hainline, Service, pers. comm.). The available information suggests that isolated suckers may be present in the Lower Klamath Lake sub-basin, including Ady canal, but that they are probably prevented from returning to the Keno impoundment and Lake Ewauna by the pumps in the Straits Drain and flow characteristics of the Ady canal.

Downstream of Keno Dam - The Upper Klamath River:

Downstream of Keno Dam the upper Klamath River consists of three primary reservoirs (J.C. Boyle, Copco and Iron Gate) and three riverine reaches. A detailed description of the reservoirs is presented in Desjardins and Markle (2000) and Fishpro (2000). The riverine reaches are: (1) Keno Dam to J.C. Boyle Reservoir (3 miles), (2) J.C. Boyle Dam to Copco #1 Reservoir (22 miles; the distance between the two Copco dams is so short, <1 mile, and the size of the reservoir at Copco #2 so small (<40 acres), that this reach is considered fish habitat), and (3) Copco Dam

#2 to Iron Gate Reservoir (1 mile). Four species of suckers are known from the Klamath River and its reservoirs : LRS, SNS, KLS, and the KSS. However, the KSS, a principally riverine and stream-dwelling species which is rare in the upper Basin, will not be included in the following discussion. Due to the high-energy character of the river reaches, the primarily lacustrine LRS and SNS are not expected to occupy them, except potentially for spawning and during movements or migrations between the various reservoirs and ultimately into the upper Basin, providing passage were available. Of the five dams, only Keno and J.C. Boyle have fish passage facilities. While the both the Keno and J.C. Boyle ladders are apparently passable by suckers to some degree, neither is designed for optimum sucker passage.

The most intensive study of suckers in the upper Klamath River reservoirs is that of Desjardins and Markle (2000) done in 1998-1999. Additional surveys were made by Coots (1965), Beak Consultants (1987), Buettner and Scoppetone (1991) and ODFW (1995); trapping in the J.C. Boyle and Keno ladders in 1988-91, provides additional information about the presence and movement of suckers in the Klamath River (ODFW undated; PacifiCorp 1997).

SNS is the only lake sucker that occurs in abundance in the Klamath drainage below Keno, and adults have been consistently collected in all three reservoirs (J.C. Boyle, Copco, and Iron Gate). Copco apparently contains the largest population of adults. However, the two lower reservoirs contain primarily larger adults (> 30 cm FL), while subadults (10-30 cm FL) are present only in J.C. Boyle. Although larval suckers have been caught in all three reservoirs, the identity of the specimens under 5cm FL is uncertain. SNS spawning behaviors have only been recorded from Copco, but there is no evidence that SNS consistently survive past 5-10 cm FL in the reservoir (Beak Consultants 1987; Buettner and Scoppettone 1991; Desjardins and Markle 2000).

LRS and KLS are apparently rare in the two upper reservoirs and have not been recorded from Iron Gate. In 1956, Coots did catch three LRS in Copco, however it is unclear whether they were abundant at the time (Coots 1965); more recent surveys have caught only a few individuals. ODFW and PacifiCorp caught only 8 LRS and no KLS passing the Keno Dam from 1988-1991 (ODFW unpub. data; PacifiCorp 1997).

J.C. Boyle Reservoir

J.C. Boyle Reservoir is 1.7 miles downstream from the Keno Dam (from upper end of reservoir). The J.C. Boyle Dam was built in 1958 at river mile 224.7. The reservoir is about 3.6 miles long, has a surface area of about 420 acres, a mean depth of about 15 ft, a maximum depth of about 50 ft, and about 7.5 miles of shoreline. Due to its shallowness the reservoir has proportionately more littoral habitat, suitable to suckers, than the other two downstream reservoirs. The daily fluctuation is about 1.5 ft, due to irregular water releases for power generation. Spencer Creek is the major tributary.

During the Desjardins and Markle (2000) study, trap netting in 1999 (April-July, 197 hrs) caught 30 identifiable subadult SNS (14-27 cm FL), a size class that corresponds to roughly 1-2 years old. Trap netting in 1998 (Sept.-Oct.,118 hrs total soak time) caught no SNS or LRS. Trammel netting in 1998-99 combined caught 18 larger subadult and adult SNS (26-40 cm FL). Only two

identifiable LRS were caught in J.C. Boyle during the study. In 1993, Reclamation sampled J.C. Boyle Reservoir eight times, collecting 20 SNS, 1 LRS, 6 KLS and 30 KSS. ODFW conducted an electrofishing survey at J.C. Boyle Reservoir on June 14, 1995. They captured 32 unidentified juvenile suckers.

Desjardins and Markle (2000) considered J.C. Boyle to be a possible sink for UKL larvae and juvenile suckers entrained into the Klamath River. J.C. Boyle was the only reservoir where juveniles (<5 cm) were plentiful. It is important to note that Desjardins and Markle used an arbitrary length of 3 cm to separate juveniles from larvae, and that they did not identify either to species. Therefore these samples could represent locally produced (Spencer Creek) smallscale suckers. The larvae and juveniles in their analysis were all <5 cm and "juveniles" averaged 3.3-3.5 cm (Desjardins and Markle 2000, Figure 9). This size class is considerably smaller than the age-0 suckers entrained at the outlet of UKL during the peak of the catch pulse, which were generally 5-17 cm in August and September (Gutermuth et al. 2000). In the reservoir study, beach seining was the only sampling method that would have captured this size class (5-17 cm FL) were they to arrive from upstream in the fall (August-October). Only 13 seine pulls were made in August 1998 and none were done in 1999; apparently, no juveniles greater than 5 cm were caught in the seines (see trap netting results above).

Copco Reservoir

Copco Reservoir is 26 miles downstream from the Keno Dam and 22 miles downstream from J.C. Boyle Dam. Copco #1 Dam was built in 1918 at river mile 198.6. The reservoir is about 4.5 miles long, has a surface area of about 1000 acres, a maximum depth of about 108 ft, and about 13.2 miles of shoreline. The daily fluctuation is about 1 foot. Shovel Creek is the only perennial tributary.

Coots (1965) caught both LRS and SNS in Copco Reservoir. However, by the 1980's few LRS were captured in sampling by CDFG (CDFG 1980, cited in Desjardins and Markle 2000). Beak Consultants (1987) conducted the first intensive study of sucker populations in Copco Reservoir in order to provide information on suckers in relation to the proposed Salt Caves Hydroproject upstream of Copco. They located a SNS spawning site in the Klamath River between Copco Reservoir and the confluence of Shovel Creek. SNS gathered at a presumed staging area in the upper reservoir during the first two weeks of April when temperatures were about 11 C. Fish then moved upstream to a presumed spawning site. Spawning activities peaked the last week of April, when temperatures were 13-15 C, and were over by mid-May. Larval suckers were first collected on May 5,th peaked mid-May, and were no longer present by 10 June. Buettner and Scoppettone (1991) sampled fish in Copco and Iron Gate reservoirs. In Copco Reservoir some very large SNS were found, some were >50 cm fork length, and up to 33 years old. No juvenile SNS were caught. Beak Consultants caught a single LRS, and Buettner and Scoppttone caught none. In 1993 Reclamation sampled Copco Reservoir and captured 10 adult shortnose suckers ranging from 43-50 cm FL. Buettner and Scoppettone (1991) suggested that poor water quality entering from upstream, scouring and dewatering of spawning areas by variable flow released from J.C. Boyle and the presence of exotic reservoir-adapted predators all had negative effects on the suckers in Copco Reservoir.

During the Desjardins and Markle (2000) study, trap netting in 1998 (October, 35 hrs) and 1999 (March-October, 219 hrs) apparently caught no more than four SNS >10 cm FL, and all would have been caught in 1999 (based on discrepancy between Table 2, total identified SNS caught and Fig. 7, size distribution of adult SNS caught in trammel nets). Trammel netting caught 6 adult SNS in 1997, 91 adult SNS (31-55 cm FL) in 1998 and 64 adult SNS (41-57 cm FL) in 1999. Only one identifiable LRS and two Klamath largescale were caught in Copco during the study. Desjardins and Markle (2000) caught only larval suckers (10-17 mm) in their combined drift net, larval trawl dip net and beach seine sampling in Copco. Essentially absent was the "juvenile" size class that was present in J.C. Boyle (3 individuals, 3-5 cm FL).

Iron Gate Reservoir

Iron Gate Reservoir is 33 miles downstream from the Keno Dam and 1.4 miles downstream from Copco #2 Dam. The dam was built in 1962 at river mile 190.1. The reservoir is about 6.8 miles long, has a surface area of about 944 acres, a mean depth of over 35 ft, a maximum depth of about 167 ft, and about 19 miles of shoreline. Due to its average depth and steep banks, the reservoir has relatively little littoral habitat, suitable to suckers. The daily fluctuation is about one foot. Fall and Jenny creeks are the two perennial tributaries.

During the Desjardins and Markle (2000) study, trap netting in 1998 (October, 56 hrs) and 1999 (March-September, 206 hrs) caught no SNS. Trammel netting caught 9 adult SNS in 1997, 2 adult SNS (about 49 cm FL) in 1998 and 11 adult SNS (41-54 cm FL) in 1999. No identifiable LRS or KLS were caught in Iron Gate during this or earlier sampling.

Desjardins and Markle (2000) caught only larval suckers (< 23 mm) in their combined drift net, larval trawl dip net and beach seine sampling in Iron Gate (1998-99). Notably absent were the 3-5 cm size class that was present in J.C. Boyle.

1.2 Status of Proposed Sucker Critical Habitat

Six critical habitat units (CHUs) have been proposed for LRS and SNS because they contain the physical and biological features essential to the conservation and recovery (Service 1994). These "primary constituent elements," include: 1) water of sufficient quantity and quality to provide conditions required for the particular life stage of the species; 2) physical habitat inhabited or potentially habitable by the suckers for use as refuges, spawning, nursery, feeding, or rearing areas, or as migration corridors; and 3) food supply and a natural scheme of predation, parasitism, and competition in the biological environment. For a more detailed discussion of the primary constituent elements, refer to the Lost River and Shortnose Sucker Critical Habitat Draft Biological Support Document (Service 1994).

CHU 1: comprises the Clear Lake watershed and includes waters of Clear Lake below the high water line, Willow Creek (including North Fork, East Fork, Wildhorse and Fourmile Creeks) and Boles Creek watersheds, which are tributaries to Clear Lake. Most of this unit is managed by the Modoc National Forest and the Service as Clear lake National Wildlife Refuge. Grazing is the primary land use. Section 7 consultations on the effects of grazing management on suckers and

bald eagles have been completed for the two Federal agencies. The condition of the watershed is good because of the management focus of the two agencies is water quality and aquatic habitat protection.

CHU 2: comprises the two Tule Lake sumps and the Lost River upstream to Anderson Rose Dam, just north of the California/Oregon border. The two sumps that are the remains of Tule Lake are managed by the Service as Tule Lake National Wildlife Refuge. Most of the land ownership in the Lost River sub-basin below Clear Lake is private. Agriculture and grazing are the primary land uses. The condition of the watershed is good to poor as are water quality and habitat conditions which are seasonally poor owing to nutrients and sediment input and degradation of water in upstream impoundments. Most of the Lost River is listed on the State of Oregon's 303(d) list for water-quality limited streams for the following criteria: chlorophyll-a (Chl-a), DO (DO), temperature, and fecal coliform.

CHU 3: comprises the Klamath River from Iron Gate Dam in California, upstream to Link River Dam, in Oregon. Land ownership in this CHU is diverse comprising Federal, State, and private lands. Land use is also diverse ranging from urban, agriculture, grazing, and forestry to waterfowl management. Impoundments comprise most of the aquatic habitat. Habitat, including water quality, is poor owing to impounded conditions and past and current land use. The water quality is impaired owing to nutrient- and *AFA*-rich water, and low DO, originating from UKL and additional input of nutrients and sediment, as well as effects of water level management and storage in downstream reservoirs. Lake Ewauna and the adjacent reach of the Klamath River also suffers from high levels of biological oxygen demand resulting from prior and continued use of the area for log storage. The Klamath River above the California/Oregon border is on the ODEQ's 303(d) list for impaired water quality criteria for most parameters, including: pH, DO, temperature, Chl-a, and ammonia.

CHU 4: comprises UKL and Agency Lake, as well as portions of the watershed west of UKL and Agency Lake from Varney Creek north to Crane Creek and east to Wood River. In terms of area, this is the largest CHU and includes considerable areas of wetlands, meadows, and riparian habitats. Most of the upland areas in this watershed are managed by Winema National Forest. Past forestry practices on National Forest lands has had an adverse effect on the catchment function, owing to soils compaction and road building. Most lands at lower elevations near the basin floor are privately owned. Forestry, agriculture, and grazing are primary land uses in adjacent areas. Water quality in UKL is seasonally poor, as described in more detail elsewhere in this document. Drainage from agriculture and pastures contributes organics, sediment, and nutrients to the lake; in summer, water temperatures are increased and inflows to the lake reduced owing to water diversions.

CHU 5: extends from the mouth of the Williamson River at UKL, upstream to the confluence of the Sprague River, then up the Sprague River to the upper limit of the presumed historic sucker distribution at the confluence with Brown Creek. On the north side of the Sprague River Valley, private portions of the Sycan River are also proposed critical habitat. Land ownership in the Sprague River sub-basin is primarily Federal in the higher elevations with some private industrial timber lands. These lands are primarily used for forestry with some grazing. At lower elevations

most of the land is private and agriculture and grazing are the primary land uses. The condition of the catchment varies from good to poor, as are water quality and habitat conditions, which are seasonally poor owing to nutrients and sediment input and water diversions. Much of the Sprague River and many tributaries are on the State of Oregon's 303(d) list for exceedence of temperature criteria. The main-stem Sprague is also listed for DO and pH. Although not listed for sediment, we believe excess fine sediment may be limiting aquatic habitat in some reaches. Some of the Sprague has been channelized and water diversions also adversely affect aquatic habitat.

CHU 6: includes Gerber Reservoir and watershed and is the only unit inhabited by SNS , but not LRS. This unit includes waters of Gerber Reservoir below the high water line, and a large portion of Ben Hall, Barnes, Barnes Valley, Long Branch, Pitchlog and Wildhorse creek. Most of the watershed is managed by the Bureau of Land Management, and Fremont National Forest to a lesser extent. Grazing and forestry are the primary land uses. Section 7 consultations on the effects of grazing management and forestry on suckers and bald eagles have been completed for the two federal agencies. The condition of the watershed is good because of the management focus of the agencies to protect water quality. A few creeks, e.g., Barnes Valley and Lapham creeks, are listed for exceedence of temperature criteria.

1.3 Analysis of the Species/Critical Habitat Likely Affected

After reviewing the information presented in the proposed action and the status of the species/critical habitat, the Service anticipates that the LRS and SNS and their proposed critical habitat will be adversely affected by the proposed action. These species/proposed critical habitats will be further considered in this opinion.

The Applegate's milk-vetch currently is threatened by habitat loss, herbivory, and competition from exotic plants. The Service does not anticipate that proposed action will affect habitat loss, which is primarily occurring near the urbanized zone of Klamath Falls, or the number of herbivores or significantly increase the spread of exotic plants. Therefore, we do not anticipate that Applegate's milk-vetch will be affected by the action. Because we do not anticipate the proposed action will affect Applegate's milk-vetch, it will not be discussed further in this opinion, except under conservation recommendations. The Service in its conservation recommendations suggests that Reclamation survey all of its properties to determine if the species or habitat is present so the agency can ensure that its actions do not adversely effect this rare plant.

The Oregon spotted frog is a candidate species and does not have protection under the ESA. The Service will make conservation recommendations for Reclamation to assist in improving the status of this species. Other than in the conservation recommendations, the Oregon spotted frog will not be discussed further in this opinion.

2.0 ENVIRONMENTAL BASELINE

This section is an analysis of the effects of past and present human and natural factors that have led

to the current the status of the species within the action area, including habitat/ecosystem conditions. It is a "snapshot" of the species' current status within the action area and does not include effects of the proposed action which are described later in this opinion.

2.1 Lost River and Shortnose Suckers

Because only a minor portion of the LRS and SNS range is outside the action area, the environmental baseline for the suckers has been previously discussed in section 2.2 "Status of Species," and will not be repeated here.

2.2 Status of Species in Action Area

This analysis examines the conservation status of the species with the action area.

2.2.1 Lost River and Shortnose Suckers

See section 2.2, "Status of Species."

2.3 Factors Affecting Listed Species and Environment within the Action Area

This baseline analysis describes factors affecting the species environment/critical habitat in the action area. The baseline includes State, tribal, local government, and private actions currently affecting the species/critical habitat, or will be contemporaneous with the proposed action. The baseline also includes unrelated Federal actions, that have been consulted on, affecting these species/critical habitat, as well as all beneficial actions.

2.3.1 Lost River and Shortnose Suckers

Sucker Health

A number of studies have been done in an attempt to better understand how sucker health affects their survival. Larval and juvenile shortnose and LRS from UKL were examined to determine anomaly rates for fins, eyes, spinal column, vertebrae, and osteocranium, and their possible associations with water quality and pesticides (Plunkett and Snyder-Conn 2000). Approximately 1,400 fish collected in 1993 were ranked on the severity of anomalies. One or more anomalies were observed in about 16% of SNS and 8% of LRS. Anomaly rates exceeding 1%, greater than rates expected from high water quality systems, were observed for abnormalities of the spine, opercles, and pectoral and pelvic fins in SNS and abnormalities of opercles and vertebrae in LRS. SNS exhibited higher rates than LRS for almost all anomalies. There were substantially more anomalies found in larvae and small juveniles than in larger juveniles. The anomalies described likely impair swimming, and could adversely affect feeding rates or avoidance of predators and adverse water quality conditions. Based on the high anomaly rates observed in this study, it is possible that age 0 suckers in UKL are more vulnerable to mortality, but no studies have been done to confirm this.

Numerous causes of high deformity rates in fishes have been identified, including genetics, pollutants, water quality, nutritional deficiencies, infectious agents, and physical and electrical shocks. Although no known studies have addressed natural anomaly rates in larval and juvenile fish, the anomaly rates in UKL suckers are much higher than expected for high quality water systems. Although vertebral and opercular anomalies could be genetic in origin, based on their highest occurrences in small suckers, other types of anomalies do not fit the genetic hypothesis. Poor water quality and/or contaminants are also likely to contribute to the frequent high proportions of abnormal suckers in UKL.

Adult SNS and LRS from UKL exhibited a wide range of physical afflictions that included eroded, deformed and missing fins; lordosis (forward curvature of the spine); pugheads; multiple types of water mold infections; redding of the fins and body caused by hemorrhage; cloudiness of the skin caused by decreased mucous production; pigmentation loss; parasitic infections of the body and gills; lamprey wounds; ulcers; cysts; gas emboli in the eyes; exophthalmos (protruding eyes); and cataracts (USGS 1997). The frequency of many afflictions were significantly greater in 1997 and 1998 than 1995 and 1996. Of the adult suckers captured from the Williamson River in April and May, 65-92% of the fish had some type of affliction in 1997-1998, whereas only 19-21% had afflictions in 1996.

In 1999, cysts were found in 35% of all SNS and 41% of all LRS, compared to 2-3% in 1997 (Markle et al. 2000a). The occurrence of the copepod parasite, *Lernaea sp.*, was at a rate of 39% for SNS and 26% for LRS, down from 84% and 56%, respectively, in 1997. Lamprey wounds were found in 17% of SNS and 30% of LRS, up from 16% and 19%, respectively. Various eye afflictions, fin damages, and other deformities were recorded for fish as well, but occurred in only a small percentage of fish captured.

Sucker Water Quality Tolerance

Periodic fish kills in UKL and elsewhere in the basin indicate that water quality frequently declines to lethal levels. Lethal effects of water quality on LRS and SNS have been verified by laboratory-performed tolerance studies (e.g., Saiki et al. 1999; Meyer et al. 2000).

Laboratory studies on effects of water quality on suckers can be divided into two exposure categories, acute and chronic. Acute studies are designed to determine short-term tolerance, for example over 96 hours, whereas chronic studies focus on longer term effects. Toxicity data are usually presented as the median lethal concentration necessary to kill 50% of the test organisms (LC-50). LC-50 values for LRS and SNS larvae and juveniles from Saiki et al. (1999) are summarized below in Table 1.

Table 1. 96-hour LC-50 (mean and 95% confidence limits)

	NH3-N (mg/l)	pH	DO (mg/l)	Temp. (E C)
LRS larvae	0.5 (0.44-0.52)	10.3 (10.26-10.45)	2.1 (2.07-2.13)	31.7 (31.5-31.9)
juveniles	0.8 (0.70-0.86)	10.3 (9.94-10.67)	1.6 (1.41–1.86)	30.5 (30.0-31.0)
SNS larvae	1.1 (0.73-1.53)	10.4 (10.31-10.46)	2.1 (1.90-2.29)	31.8 (31.7-31.9)
juveniles	0.5 (0.34-0.82)	10.4 (10.22-10.56)	1.3 (1.15-1.55)	30.3 (29.4-31.3)

The most comprehensive laboratory study on sucker acute water quality tolerance was done by Saiki et al. (1999). Comparison of 95% confidence limits indicated that, on average, the 96 hour LC-50s were not significantly different from those computed for shorter exposure times (i.e., 24 hour, 48 hour, and 72 hour) (Saiki et al. 1999). LC-50s for the four water quality parameters did not vary significantly between species. Also, there was little difference between larvae and juveniles except that larvae were significantly more sensitive than juveniles to low DO concentrations (referred to as "hypoxia"). No attempt was made to examine the effects of combined parameters.

When exposed to the highest pH treatments, LRS and SNS larvae and juveniles experienced convulsions, erratic swimming, and production of excessive mucus (Saiki et al. 1999). Dead and dying suckers showed hemorrhaging from eyes and gills, and ruptured eyes. High levels of un-ionized ammonia also caused gill bleeding; juvenile were hyperactive but larvae comatose. Lethal temperatures resulted in bloating and floating on the surface. Hypoxia resulted in swimming difficulties and gasping behavior.

The situation regarding ammonia toxicity is complex and not well studied for suckers, especially at low pH and temperatures that migh be present in winter. The USEPA 1984 ammonia AWQC document details the relationship of un-ionized ammonia toxicity to temperature and pH for several species including fathead minnow and rainbow trout. They all show a relationship where un-ionized ammonia becomes more toxic at lower temperatures and lower pH conditions. This relationship is complex because a greater percentage of the total ammonia is in the un-ionized fraction as pH and temperature rise. The concern will be what happens when pH and temperature decline in UKL and other Project reservoirs in the fall when total ammonia is still high (as in 1996 –1998). The Saiki et al. (1999) studies were all conducted at pH values between 9.0 and 9.5 and temperatures between ~20 and 25 C. It is possible that UKL conditions in the fall, water temp. <20 and pH between 7.0 and 9.0 could still be the bases for un-ionized ammonia toxicity to suckers.

One study has addressed chronic effects of water quality on suckers. Meyer et al. (2000) examined 14- and 30-day chronic effects of low DO, and elevated pH and ammonia on larval and juvenile LRS. Mortality thresholds were found to range from 1.5-2.0 mg/l DO, >10 pH, and 0.37-0.69 mg/l ammonia. These levels correspond well with those obtained in previous studies. Contrary to expectation for fish chronically exposed to toxicants, LRS generally did not display sub-lethal responses to low DO concentrations, elevated pH, or elevated ammonia concentrations

based on the three traditional chronic-toxicity endpoints used (growth, whole-body ion content, and swimming performance). In the 14-day sub-lethal ammonia/sub-lethal DO test, mortality did not decrease significantly and no sub-lethal effects were observed and there was a slight but significant decrease in sodium content at pH 10 levels held for 30 days.

In the above-mentioned experiment, gill histopathology was sometimes more sensitive than the three traditional chronic endpoints, i.e., growth, whole-body ion content, and swimming performance (Lease 2000). In the ammonia test, statistically significant structural changes occurred in gills of LRS larvae exposed continuously to un-ionized ammonia concentrations 3.5 times lower than the lowest concentration at which significant mortality and growth effects occurred. Changes in gill structure that were quantified included significantly increased oxygen diffusion distance and increased thickness of secondary lamellae—the primary site for respiratory and ion regulation. Additionally, qualitative structural changes were observed, including increased number of chloride and mucous cells, the appearance of mitotic figures, and infiltration of white blood cells into the lymphatic space (Lease 2000). However, no statistically significant structural changes were detected in gills of fish exposed to the highest pH of 10.0.

Lease (2000) postulated that the interaction between ammonia and low DO might be synergistic, because exposure to ammonia caused gill structural changes, specifically increased diffusion distances, which would exacerbate respiratory stress during periods of low DO. Lease also pointed out that high pH would be synergistic as well, because at a pH >9, ammonia excretion can be inhibited and it would thus concentrate in tissues. Therefore, during periods of high pH and high ammonia, suckers may experience greater stress. Periods of low DO and high ammonia and pH in UKL occur throughout the summer, suggesting a potentially long period of stress (Loftus 2001).

Another toxicity test was performed to determine the effects of the pathogenic bacterium, *Flavobacterium columnare*, on LRS juveniles following 30-day sub-lethal ammonia exposures (Morris et al. abstract; Snyder-Conn et al. in prep.). Sucker die-offs that occurred during late summer of 1995-1997 were usually associated with *F. columnare*. This ubiquitous pathogen appears to be only a problem when fish are stressed by poor water quality conditions and warm temperatures. Test fish were subjected to one of four sub-lethal ammonia concentrations ranging from 0.006 to 0.43 mg NH3-N/l, at a pH of 9.5 for 30 days. After the 30 days, test fish were challenged with the bacterium and continued exposure to ammonia. Results showed survival of sucker exposed to *F. columnare* decreased relative to control fish, but contrary to expectations, survival increased with increasing ammonia concentrations. Results of this study suggest that there may be a decrease in *F. columnare* virulence at high ammonia concentrations, and/or the fish may exhibit a compensatory response that increases immunity to the bacterium. In nature, the situation is vastly more complex, since increased ammonia is only one of many stressors affecting suckers during the summer and concentrations are rarely constant for more than a few days (Loftus 2001; Welch and Burke 2001).

Histopathology of the juvenile LRS used in the above ammonia and *F. columnare* challenge experiments, was also studied (Foott et al. 2000). They found three abnormalities: gill epithelium separation and swelling, and clear droplets in kidney tubular cells. Gill separation was most

prevalent at the lowest ammonia concentrations, 6 ug NH3-N/l, and was believed to be a reversible condition resulting from localized edema.

There is only a single study where laboratory lethal levels of water quality on suckers can be compared with those measured *in situ*. Martin placed a series of cages containing juvenile LRS at various sites in UKL (Martin1997; Martin and Saiki 1998). A datasonde recorded water quality parameters at each site over each 4-day test interval. Results showed that mortality occurred at all sites but there was a significant difference among sites. When mortality rates were compared to water quality parameters, rates were significantly correlated with increased pH and un-ionized ammonia, and low DO concentrations; however, low DO showed the highest correlation with mortality. Where mortality was >90%, DO levels had gone below 1.4 mg/l. This corresponds with the lower lethal DO concentrations cited above. In Martin's study, caged fish were found to be slightly less susceptible to high pH than those under laboratory conditions. Martin found no mortality in caged fish when pH averaged 10.3 and reached nearly 10.8; whereas 9.9 to 10.7 were average lethal pH levels measured in the laboratory studies cited above. Temperatures reached 28.0 E C and ammonia 0.65 mg/l in Martin's experiments and were below lethal levels. Martin's in situ-measured lethal levels for the four water quality parameters showed that laboratory- and field-measured results are similar enough to be useful for predicting what levels are likely to cause mortality.

Terwilliger et al. (2000) examined age 0 sucker growth rates in 1997 to find if they were correlated with various water quality parameters. They found that growth was highest at warmest temperatures but once pH and un-ionized ammonia concentrations became high, growth was reduced. The authors considered this to mean that high un-ionized ammonia produced a sub-lethal negative effect on juveniles sucker growth. This is supported by data showing un-ionized ammonia concentrations in 1997 at month-long levels considered stressful for juvenile suckers. Water quality in 1997 apparently reached lethal levels since fish kills did occur, as discussed above.

Summary: Sucker Water Quality Tolerance

Laboratory and in situ studies show that suckers, although relatively tolerant of adverse water quality, are nonetheless killed when conditions reach critical levels. Mortality could occur if suckers were exposed to DO concentrations < 2.3 mg/l, pH> 9.8, temperature >29.4E C, and un-ionized ammonia >0.34 mg/l (Monda and Saiki 1993, 1994; Bellerud and Saiki 1995). However, in situ experiments strongly suggest that hypoxic conditions in UKL are most likely to produce high mortality of larval and juvenile suckers. Although both pH and un-ionized ammonia can reach in situ levels above those shown to be lethal in the laboratory, these parameters may be transient and thus the exposure time is too brief to be lethal.

As pointed out in Reclamation's BA, results from laboratory water quality mortality studies should be viewed cautiously. Such experiments may under- or over-estimate mortality that might occur in situ, and they tell us almost nothing about sublethal effects. We would, however, emphasize that laboratory-measured LC-50 values are perhaps best viewed as red flags that should alert us to potential problems. Such studies, even done under the most exacting conditions cannot, nor are

they meant to, mimic real-life conditions where there are complex spatial and temporal variations in water quality parameters as well as even more complex behavioral, predator/ prey, parasitic and pathogenic, and competitive interactions. In situ studies like that of Martin (1997) done over short time periods where multiple parameters are measures simultaneously, are perhaps the best available way to examine the relationship between water quality and mortality; however, such experiments still fail to capture the long-term effects or the myriad ecological factors involved. We posit that laboratory and in situ studies provide ample reason to be concerned about the threat water quality poses to LRS and SNS and on the ecosystem on which they depend.

Upper Klamath Lake Sucker and Other Fish Die-offs

The laboratory and in situ studies discussed above indicate that water quality in UKL may at times be stressful or even lethal to suckers and other species. This is supported by other observations showing that fish kills may not be unusual in UKL. When ichthyologist, C.H. Gilbert visited the lake in June 1894, a fish kill was apparently underway, because many dead and dying fish were observed (Gilbert 1898). Fish kills were recorded, however, in 1932, 1971, and 1986 (Buettner 1997). It is likely that other fish kills occurred in the lake in the 19th and 20th centuries but were not reported. However based on available records, these events may have been infrequent or involved few fish and thus were not sufficiently noticeable to be reported.

In August 1986, Bienz and Ziller (1987) observed 100 to 200 adults suckers in the area of Pelican Bay influenced by input of spring water. Water quality in UKL at the time was poor and they postulated that the suckers were there to avoid the poor conditions. During late July and August 1986 there were several reported fish kills involving suckers. Two LRS found dead during this period were ones that had been tagged in the William/Sprague rivers in 1985. Other small, localized fish die-offs have been observed annually on UKL since 1992 when extensive research and monitoring activities began. Small, localized, short-lived, fish kills now occur annually in UKL, in addition to the larger catastrophic fish kills.

Upper Klamath Lake Sucker Die-offs, 1995 and 1996

Three large sucker die-offs were documented in UKL in 1995, 1996, and 1997. In 1995, the die-off occurred during September and October with 378 LRS and 124 SNS collected. A detailed discussion of the 1995 die-off was provided in Reclamation (1996a), in Perkins et al (2000b), and Loftus (2001).

During July 1996, dead suckers began appearing in UKL, presumably because of stressful conditions associated with poor water quality, e.g., low DO, and a bacterial disease outbreak. Between August 8 and October 3, 1996, some 6,049 dead suckers were collected (USGS 1996). The numbers peaked in Pelican Bay and Odessa Creek, the most frequently monitored areas, during the weeks of August 26 and September 2. Lake-wide, the greatest numbers of suckers were collected the week of September 2. The weekly number of LRS and SNS captured was similar among the two species.

Initial collections occurred from August 8 to August 20 in the clear water areas of Pelican Bay,

and Odessa Creek. By August 23, it was apparent that the fish kill was becoming more widespread throughout the lake. Lake-wide surveys were attempted on August 26 and August 29; however, the quantity of dead suckers encountered precluded complete coverage of the lake on both occasions. Subsequent collections were made at various areas in the lake and along the shoreline. Fish kill monitoring in the clear water areas of Pelican Bay and nearby creeks (Harriman, Odessa, Short) was more rigorous and systematic than for the rest of the lake. These areas were thoroughly collected at two to four day intervals throughout the fish kill. Most fish were dip-netted off the bottom, with some found floating or along the shoreline.

It is difficult to assess the spatial distribution of the fish kill in 1996. Suckers were found dead throughout UKL excluding Agency Lake. Highest densities of fish were also collected along the south shoreline (USGS 1996). The fish found in this area appeared more highly decomposed than those from other areas of the lake. We suspect that most of these fish died in the northern areas of the lake and were carried by wind-induced currents to the south end of the lake. Higher numbers of suckers were also collected from the eastern shoreline. Prevailing winds during this period were from the northwest. Hundreds of dead suckers were seen floating on the surface and hidden in dense beds of submerged aquatic vegetation in Pelican Bay. Most of these suckers were not collected.

The approximately 6,000+ suckers collected during the 1996 fish kill undoubtedly represent only a small fraction of the number that died. Due to the poor water clarity in most lake areas, only fish floating or littered along the shoreline could be collected. Most likely, large numbers of dead fish sank to the bottom like those observed in the clear water areas. It is suspected that many dead fish initially sank to the bottom and then floated up after a period of days after bacterial decomposition occurred and the body cavity filled with gases. Attempts were made to evaluate dead sucker floating/sinking mechanisms to determine if estimates could be made of the percentage of dead fish floating (D. Perkins, USFWS, pers. comm.). Experiments were highly variable and inconclusive.

At the south end of the lake, most fish were collected while walking along the shoreline. In this effort, many fish were found hidden in bulrush stands and others were partially or completely buried in the ground at the water/shoreline interface. Collections along the shoreline in other areas of the lake were less thorough with only fish readily observed by boat being collected. Based on the observation of field biologists, it was speculated that the number of fish collected may have represented only 2.5 to 10% of the suckers that were floating, which does not include dead fish that sank to the bottom and were never observed (USGS 1996).

Fish less than 30 cm FL were conspicuously absent from the fish kill. Also, smaller fish were not obvious among the sick fish in the clear water areas. On one occasion, large numbers of small chubs were seen floating on the lake; however hundreds of birds had eaten all the fish by the next day. Large concentrations of fish-eating birds have been seen on many occasions during the late summer months feeding on small fish. Thus, the thousands of birds in the vicinity of UKL during the fish die-off may have effectively consumed most small fish that died in the fish kill. OSU biologists noted a substantial drop in age 0 sucker cast net catches in September and October suggesting these fish were affected by the die-off (Simon and Markle 1997).

The length frequency distribution of LRS captured in the 1996 fish kill was generally similar to distribution of fish captured in the 1996 spawning assessment from the Williamson River. Fish from 40 to 50 cm were the most numerous size range for both the fish kill and the spawning run. The length frequency distribution of SNS greater than 30 cm FL that were captured in the 1996 fish kill were shifted about 3 cm larger than the distribution of fish captured in the spawning assessments of the same year. In the spawning assessment, SNS ranging from 32 to 40 cm were the most common sizes, while in the fish kill most were 35 to 44 cm. The difference in length distribution appears to be related to a non-random sample of the population for either the spawning group or the fish kill. When die-off frequencies are plotted for fish collected at springs and lake locations, it is apparent that the springs fish were larger (Perkins et al. 2000b). Several potential hypotheses to explain this are discussed in USGS (1996).

It appears that a bacterial disease "Columnaris,"caused by *Flavobacterium columnare*, was the main infectious disease involved in the sucker die-offs but there may be other factors along with water temperatures that were predisposing the fish to infection (Holt 1996; Foott 1996). In 1996, pathological examinations were conducted on 26 sick and dying suckers at the Oregon Department of Fish and Wildlife Pathology Lab at Oregon State University. Columnaris bacteria were isolated from 24 of 26 specimens. Columnaris gill lesions were found in 78% of the LRS (9 total) and 77% of the SNS (17 total). No viruses were detected from these fish. Fungi were found in 58% and APS bacteria in 80% of the fish. Up to 23 leeches were attached in the mouth cavity producing ulcers and hemorrhaging. Some anchor worms were also attached to the base of the fins. Internally, the fish appeared normal except for presence of white trematode cysts on the heart.

Histological examination of 12 moribund and 3 normal suckers were conducted by the US Fish and Wildlife Service Fish Health Center, Anderson, California (Foott 1996). Lesions characteristic of bacterial infections were seen in 14 of 15 fish. All of the fish showed kidney abnormalities, specifically, degeneration of a specific region of the renal tubule. The degenerated tissue observed in the kidney is indicative of toxic tubular necrosis which can be caused by heavy metals, pesticides and other toxins (Foott 1996).

Data indicate that the 1996 die-off was linked to a combination of meteorological and biological conditions (Perkins et al. 2000b). Specifically, warm weather and relatively calm conditions during July and August led to warm water temperatures, stratification of the water column, and increased biological activity. Warm temperatures increased respiration rates and sediment and water column DO demand. *AFA* populations that bloomed in June were generally declining. A lack of wind mixing likely reduced aeration and consequently fish were exposed to stressful levels of low DO leading to disease outbreaks and mortality.

In reviewing the Klamath Falls meteorological data records, weather conditions before and during the 1996 die-off were unusual. For example, the mean monthly July temperature was 73.5E F, making it the second warmest in 69 years of record at the Klamath Falls airport. The August mean monthly temperature, 70E F, was ranked 11th over the 69-year record. Warm weather was also associated with previous fish die-offs in 1995, 1986, and 1971.

Water temperature in UKL has been shown to be closely associated to air temperatures (Wood et al. 1996). Because UKL is so shallow and generally well mixed, water temperatures quickly respond to changes in air temperature. Lag time between changes in air temperature and water temperature appear to be only a few days during the summer.

Klamath Falls wind data indicate that July 1996 was ranked 4th out of the last 27 years for lowest mean monthly wind speed (3.2 mph). August was also a relatively calm month with an average monthly wind speed of 3.0 mph (5th out of 27 years). Wind records from the Klamath Falls airport generally indicate that winds are mostly light during the summer. However on a daily basis, winds vary, but typically are highest during the afternoon and early evening hours.

Cloud cover was also examined as it related to fish die-offs. In 1996, July and August were ranked 7th and 8th respectively as the sunniest months from the last 27 years. Sunny days can also be generally correlated to warm air temperatures during the summer. Sunny days generally dominate during summer months in all years.

Extensive water quality monitoring was conducted on UKL during 1996 to evaluate lake conditions during the die-off. Beginning about mid-July and extending through August, *AFA* populations were generally declining, with a large biomass of dead and dying *AFA* being present. Associated with the *AFA* decline were low DO concentrations. With calm conditions, stratification was common, and near bottom DO was frequently <5 mg/l (Perkins et al. 2000b).

From June through August 1996, un-ionized ammonia levels were generally higher than any of the previous five years sampled. Mean lake-wide ammonia concentrations were 70-95 ug/l (Perkins et al. 2000b). Although these concentrations are well below the acute lethal levels for suckers of >0.5 mg/l, they may have contributed to stressful conditions prior to the sucker die-off (Loftus 2001).

Upper Klamath Lake Sucker Die-off 1997

Another major fish die-off occurred in UKL in late summer 1997. The first signs of an impending fish kill were seen in mid-July, when USGS noted a substantial increase in trammel net mortalities. Also, during the week of August 4, Cell Tech's fyke net collection of suckers exiting the lake via the Link River Dam, increased sharply from tens of suckers in previous weeks to over 400 suckers. This exodus peaked the week of August 11 with >1000 fish (Gutermuth et al. 1998b). During the week of August 11 chubs and suckers were first found dead throughout UKL. Suckers were also observed congregating and dying at freshwater inflow areas at Pelican Bay, Williamson River, and Odessa Creek. Dying suckers were observed to have numerous external parasites, primarily anchor worms, and to be lethargic in nature.

Over 2,300 large juvenile and adult suckers were collected in 1997, including 1,251 SNS and 885 LRS. The largest numbers of fish were collected from Pelican Bay (USGS, unpub. data). Substantial numbers were also gathered from the lower Williamson River, Ball Point and the mouth of Shoalwater Bay in the northern portion of the lake. Dead suckers were collected from July 23 to September 22 ,with a peak in late August. Adult blue chubs and tui chubs were the most

frequently encountered fish littering the shoreline of UKL and lower Williamson River, and accounting for approximately 64% and 27% of the dead fish respectively. Dead redband trout, sculpins, and yellow perch were also collected. Approximately 90 trout were collected from the Pelican Bay/Harriman Creek area and lower Williamson River.

Dead and dying fish were provided to the ODFW Pathology Lab, and the Service Fish Health Center for examination (Foott 1997; Holt 1997). Columnaris was recovered from 80% of the fish submitted and Learnea copepod (anchor worms) infestation was observed on 73% of the fish. No viruses were isolated. Foott (1997) also noted a high prevalence of kidney abnormalities.

Use of Water Quality Refuge Areas in Upper Klamath Lake by Suckers

The high Cascades that form the western boundary of the UKL watershed can have substantial snow pack in winter. The porous volcanic soils on the eastern slopes ensure that a large portion of the runoff will enter the regional ground water system when it melts, and consequently there are numerous springs and ground-water fed creeks in the area. The eastern base of Pelican Butte has an especially high number of springs and creeks (Geiger et al. 2000), including Fourmile and Rock Creek, and Harriman and Malone springs. Additional inflow comes from springs and creeks a few miles farther north that flow south, including: Cherry and Sevenmile creeks, and Crystal, Blue, Mares Eggs, Fourmile, Jacks, and Tiger Lily springs. All of these inflows enter UKL near Pelican Bay.

These inflows can have much higher water quality (higher DO and lower temperature, pH and ammonia) than the lake, especially in summer. Therefore it is not surprising that this area near Pelican Bay and nearby Fish Bank has been suspected of being a water quality "refuge" for suckers and other fishes, including native redband trout. Suckers have been seen in the clear waters of this area; however it appears that these suckers are mostly sick or dying. Radio-telemetry shows that most adult suckers predominately use the area outside of Pelican Bay where depths are adequate and the water is more turbid, as described below.

In August 1986, Bienz and Ziller (1987) observed adult suckers in the area of Pelican Bay at the time UKL was experiencing poor water quality. Since 1986, other researchers have noted suckers using Pelican Bay, Wood River, Odessa Creek, and the mouth of the Williamson River when water quality is poor in the rest of UKL. A summary of information related to sucker use of freshwater inflow areas in UKL was presented in the BA of PacifiCorp and The New Earth Company operations associated with the Klamath Project (USBR 1996a). New information after 1995 was generally consistent with previous observations.

Adult suckers frequently used lake areas that are influenced by inflows during the summer (Peck 2000; USBR 1996a). They were typically located within a couple miles of Pelican Bay and the Fish Banks area. Other fish were found near the mouth of the Williamson River, Odessa Creek, Short Creek and Wood River. During 1994, many of the radio-tagged suckers concentrated near the entrance to Pelican Bay during July when water depths were 3-4 ft. In August and September when lake levels dropped below 4138 ft, radio-tagged suckers moved further offshore to areas of lower water quality. Bottom elevations off Pelican Bay vary from about 4133 to 4136 ft. This

suggests that inadequate depth cover may force suckers to leave areas of good water quality and move into areas of adverse water quality.

During the 1996 and 1997 die-offs sick and dying adult suckers were observed in Pelican Bay, Odessa Creek, Williamson River, and Short Creek. Two and four radio-tagged SNS remained in close proximity to the Wood River in Agency Lake throughout the summers of 1996 and 1999, respectively (USBR, unpub. data). In 1996, the Klamath Tribes tagged sick suckers in Odessa Creek in an attempt to determine if they would recover. Almost all tagged fish were found dead in Odessa Creek within a couple of days. These data suggest that suckers generally enter the clear-water inflow areas only when they are extremely sick and these locations might be considered dying grounds.

Suckers may make some use the Williamson River/Sprague River as a refuge to poor water quality based on the one radio-tagged fish and observations in the 1960's when substantial numbers of suckers were seen in the Williamson and Sprague rivers during August (Golden 1969). There were no reported sucker die-offs associated with these observations. Suckers are rarely observed in these areas except possibly during the spawning season. Sick and dying fish have been documented in these areas from previous fish kill events (1971, 1986, 1995) (Buettner and Scoppettone 1990; USBR 1996a). Suckers collected from the clear water areas were generally larger specimens (USGS 1996; Perkins et al. 2000b). Samples collected from other areas around the lake included a wider range of sizes. Dead suckers and chubs were also collected in the C-Canal drop area during August and September (Gutermuth et al. 1997). About two-thirds of these fish were juveniles <30 cm FL and one-third were adults. It appears that most of the smaller fish died in the canal rather than in the lake. Hundreds of adult suckers were also collected in front of a log boom at the entrance to the A-Canal. Few small suckers were collected from the log boom.

Although sucker die-offs have received the most attention, adverse water quality will stress fish prior to causing mortality. Loftus (2001) has evaluated the Klamath Tribes and USBR long-term water quality data set for UKL to assess when water quality would likely could cause stress. Such stress, although not immediately lethal could have significant adverse short-term and long-term effects (e.g., reduced growth and reproduction; increased susceptibility to disease, parasitism, physical abnormalities, and predation) and could be a factor leading to mortality. During the period from 1990 to 1998, he found that total stress days in summer ranged from 24 to 104. Low DO and high pH were the primary factors that would cause stress, with un-ionized ammonia likely being less significant before 1996. Beginning in the spring of 1996, un-ionized ammonia concentrations became substantially and consistently higher in UKL. They often reached sublethal levels at times when DO and pH would also be stressful (Reiser et al. 2001; Loftus 2001). One or more of the stressors occurred over several weeks at high levels prior to and during the die-offs in 1995-1997. Cumulative stress-day values were highest during July and August 1995 and 1997 when fish kills occurred. Stress was also likely to be high during July and August 1992 and 1994 when very low DO values were present. These data indicate that even though large fish kills did not occur annually in UKL, suckers were likely to routinely stressed.

Upper Klamath Lake Sucker Die-offs: Summary

Perkins et al. (2000b) discussed the water quality conditions associated with the 1995-1997 fish die-offs. They concluded that the main cause of the die-offs was hypoxia caused by collapse of AFA blooms which triggered hypoxic conditions that became mixed throughout the water column. Susceptibility to hypoxia was probably enhanced by prior or simultaneous stress due to exposure to high pH and high un-ionized ammonia concentrations and low DO levels during the prior summer months. The summers of 1995-1997 experienced periods of low lake mixing and very low DO levels, due largely to the DO demand of rapidly declining and dying *AFA* blooms and usually higher ammonia levels. Temporary, high water-column stability created by low winds resulted in a lack of mixing and aeration.

Perkins et al. (2000b) attributed the direct cause of the fish die-offs to be low DO, because pH and hence, un-ionized ammonia (the ratio of un-ionized to ionized ammonia increases with pH) had declined to relatively low levels by the time the kills peaked due to large declines in *AFA* biomass. Other studies, e.g., Martin and Saiki 1999 and Saiki et al. (1999), have also considered that the primary water quality factor responsible for UKL fish kills is hypoxia. The kills occurred with mixing and very low DO concentrations due largely to the DO demand of the dying *AFA* blooms. The principal cause for the low DO values in July-August 1995, 1996, and 1997 that triggered the fish die-offs, in addition to bloom collapse, was high water column stability. Prior to the kills, there were low off-bottom DO levels, which were subsequently transmitted throughout the water column during mixing, thus there may have been no depths at which adequate DO levels occurred; therefore suckers and other fish may not have been able to avoid the lethal conditions.

Fish kills are not related to lake levels. They occurred in years of average, above-average-and below average, median August elevations (Welch and Burke 2001). Median August elevations are the most appropriate date for comparing lake levels and fish kills because August was the month when most kills occurred. Lake elevations in 1971 and 1995 were above average; 1986 was average, and 1997 and 1996 were below average. Therefore, there is no clear relationship between lake elevations and fish kills. In 1992 and 1994, when two of the lowest elevations occurred, significant fish kills were not detected, but DO levels were low (Welch and Burke 2001); had weather conditions been different, such as low winds speeds and higher temperatures, there is a high likelihood that there would have been significant die-offs. Data show that 1992 and 1994 were windy (Welch and Burke 2001). Under these conditions ammonia and DO levels are moderated by mixing (Welch and Burke 2001).

Although August appears to be the month where fish kills are most likely to occur, water quality was adverse in September and October 1996, 1997, and 1998, owing to a late summer bloom decline (Loftus 2001; Welch and Burke 2001).

Based on the currently available data, it appears that no obvious correlation exists between UKL elevations and fish die-off events. This is not unexpected since many complex factors, for example, size and timing of bloom initiation and duration, weather conditions (especially wind and temperature), presence of disease organisms of differing virulence, exposure to stress, and other

factors, are involved in the complex series of events leading to and causing the die-offs. Low lake levels per se do not cause fish kills; they can however, contribute to conditions that cause fish kills. Low lake levels can contribute to conditions that promote *AFA* blooms chiefly by increasing average light intensities in the water column and aiding internal nutrient loading, and can also worsen water quality conditions through a number of mechanisms, but chiefly by reducing lake volume/surface area ratios which reduce DO levels and increasing pH and ammonia concentrations, as discussed in detail below. Based on well documented limnological relationships (e.g., light intensity and internal loading increase with decreasing depth, and DO in the water column declines with decreasing depth) (see Welch and Burke 2001 for citations), and because UKL is so shallow, small changes in depth may have a disproportionally large effect.

In the 1986 sucker die-off, most suckers collected were large, old LRS. However, two years after the die-off substantial numbers of younger LRS were documented in the spawning run that were not noted in 1986. In 1995, 378 Lost River and 124 SNS were collected in a die-off. This compares to 2,213 and 1,912 LRS and SNS respectively in 1996. The ratio of Lost River to SNS was 3 to 1 in 1995 and 1.2 to 1 in 1996. This data suggests differential vulnerability to mortality each year. Also, the small number of suckers less than 30 cm FL may be related to differential mortality with larger fish affected more than small fish.

Fish die-off and radio telemetry information from the last five years have led to a hypothesis, discussed in Reclamation's BA, that the UKL sucker populations may be limited by summertime habitat. Reclamation noted that in summer, radio-tagged suckers were concentrated in the northern one-third of UKL, mostly above Bare Island and a small group near the mouth of the Wood River in Agency Lake (Peck 2000). Reclamation suggested that with evidence of frequent recruitment from 1988 to 1996 and a large 1991 year-class, suckers numbers may have exceeded the carrying capacity of the limited summer habitat and led to the 1995-1997 sucker die-offs. We concur with the hypothesis that habitat is limited, but not that carrying capacity is exceeded because of too many fish. Instead we suggest that owing to widespread, lethal, water- quality conditions in UKL and lake level management which reduces lake depth, suitable deepwater habitat for adult suckers in UKL varies in extent, and when water quality is severe it can at times decline to zero.

Upper Klamath Lake Water Quality

The hypereutrophic status and resultant seasonally adverse water quality in UKL is well documented (USACE 1982; Kann and Smith 1993; Kann 1993a,b; Martin and Saiki 1999; Perkins et al. 2000b; Welch and Burke 2001; Walker 2001). Extensive blooms of the cyanobacterium *Aphanizomenon flos-aquae* cause significant water quality deterioration due to photosynthetically elevated pH (Kann and Smith 1993) and to both supersaturated and hypoxic concentrations (Perkins et al. 2000b;Welch and Burke 2001; Walker 2001). *AFA* is the dominant primary producer in UKL, comprising >90% of the primary producer biomass during blooms. Both high pH and low DO reach levels in UKL known to be lethal to suckers, and as such are important parameters affecting survival and viability of native fishes. Bioassays (discussed above under " sucker water quality tolerance") have shown that pH values >9.55 caused a loss of equilibrium in juvenile SNS (Falter and Cech 1991), and that values >10.3 proved lethal to larval and juvenile SNS and LRS (Saiki et al. 1999). Bioassays also show that DO levels <2.4 mg/l are lethal to

larval and juvenile SNS. It is important to note that sub-lethal effects are likely to occur prior to reaching the lethal levels described above (Kann and Smith 1993; Reiser et al 2001). Meyer et al. (2000) and Lease (2000) documented structural changes in the gills of larvae exposed to un-ionized ammonia concentrations 3.5 times lower than the lowest concentration at which significant growth and mortality effects occurred. Swimming performance of larval LRS was reduced at pH of 10.0.

Lake volume and mean depth have a direct effect on physical, chemical, and biological processes. There is a direct reduction of habitat available for fishes as lake level is lowered, particularly the reduction in shoreline rearing habitat of larval and juvenile endangered sucker species (Dunsmoor et al. 2000; Klamath Tribes 1995; Reiser et al. 2001). In addition, lowered lake elevation and volume can exacerbate various productivity- related water quality problems.

The Klamath Tribes and Reclamation have been intensively monitoring limnological conditions in UKL since 1990 to document temporal and spatial variability in water quality, nutrients, and *AFA* biomass. This work was also aimed at identification of major factors affecting *AFA* bloom dynamics and associated water quality including lake level regulation. Several reports have been completed analyzing this information (Kann 1993a, 1993b; Kann and Smith 1993; Klamath Tribes 1995; Jassby and Goldman 1995; Wood et al. 1996; Kann and Smith 1999; Kann 1998; Welch and Burke 2001; Loftus 2001). The following section attempts to summarize pertinent lake elevation regulation-related information discussed in the references cited above.

Effects of *Aphanizomenon flos-aquae* and Lake Level Management on UKL Water Quality

The relationship of *AFA*-induced water quality changes to fish growth and survival in hypereutrophic lakes and how that relationship is affected by lake elevation is important in UKL because it has such an effect on the lake ecosystem (Reiser et al. 2001). High nutrient loading promotes correspondingly high production of algae and *AFA*, which, in turn, modifies water quality characteristics that can directly diminish the survival and production of fish populations. Lowered lake elevations may increase *AFA* production and worsen water quality. The following chain of causal relationships and mechanisms, which is supported by the scientific literature, is characteristic of hypereutrophic lake systems such as UKL.

Nutrients and Light à*AFA* GrowthàWater QualityàFish Survival

Under conditions of high nutrient input and adequate light, *AFA* biomass increases until some factor, either light, nutrients, grazers, or other factors, limits further growth. As biomass increases, the available soluble forms of nitrogen (N) and phosphorus (P) decrease, because the nutrients are accumulated in the biomass, and are therefore unavailable for further biomass increase. The nutrient in shortest supply, relative to growth requirements, at a given time is the limiting nutrient. Because *AFA* can fix atmospheric nitrogen, its growth is considered not to be limited by nitrogen concentrations (Reynolds 1986); however, this does not necessarily mean that if additional nitrogen were available it would not lead to an increase in *AFA* biomass. A TMDL was recently determined for UKL that considered the role of nitrogen in the lake, but focused on limiting P input to improve water quality (Walker 2001). Analysis of *AFA* growth and loss rates in relationship to

light availability, as well as results from the literature, show that relative decrease in *AFA* biomass would be substantial at a mean depth of 2.7 m (4143 ft) compared to a mean depth of 1.5 m (4140 ft) (Welch and Burke 2001).

During *AFA* and other phytoplankton blooms, particularly when coupled with high rates of nighttime respiration, DO can vary considerably over a 24h period. Also during blooms, available carbon dioxide in the water is used and pH rises to levels >10, which can be lethal to fish. Such pH and DO events can occur throughout the summer in shallow hypereutrophic water bodies like UKL where *AFA* growth conditions are optimal. Following these blooms, when high levels of *AFA* and other phytoplankton biomass die-off, the respiration of phytoplankton and the microbial degradation of this biomass and additional DO demand by organic-rich sediment can deplete DO and increase ammonia concentrations to levels that likely reduce growth of and are stressful, or are lethal, to fish. The extent of DO depletion, and pH and ammonia increase by these processes can be elevated by shallow depths, i.e. the potential for stress-inducing water quality is always present in proportion to *AFA* production and the lake volume/sediment area ratio. These processes are also affected by temperature and wind mixing, as described below.

The Klamath Tribes measured light extinction on several occasions throughout the summer in 1994 and correlated it with Secchi disk depths (Kann 1998). They documented that light intensities are below levels needs for plant growth below a depth of about 3 ft. This pattern was very consistent for all sites and years during the June-September growing season. As a result, *AFA* productivity generally becomes light limited below 3 ft such that nearly all productivity is relegated to the upper few feet of the water column. Thus in a mixed situation, which frequently occurs in UKL owing to shallow depths, *AFA* cells spend a proportion of time at depths >3 ft where respiration exceeds photosynthesis. As the ratio of photosynthesis/respiration declines until it becomes <1, growth slows and eventually ceases. The deeper the water column the greater the proportion of time *AFA* growth will be light limited, thereby reducing growth and photosynthetically-elevated pH (Kann and Smith 1999), and affecting the timing and magnitude of blooms in a positive way with respect to water quality (Welch and Burke 2001; Walker 2001).
Although *AFA* can regulate its buoyancy (Reynolds 1986), wind speeds that are typical of UKL during the summer, mix the cells into the water column (Kann, Klamath Tribes, pers. comm.). This is consistent with observations of cyanobacteria in other lakes (Reynolds 1986; Welch and Burker 2001).

In addition, any pH reduction theoretically can be expected to further reduce internal phosphorus loading, as discussed below. At any time during the growing season when light is limiting, the pH response to a given *AFA* biomass will be incrementally less when depth increases. Because UKL elevation reductions as little as 3ft translate into about a 40% reduction in mean depth, these changes in lake levels are not small effects and can decrease the impact of poor water quality events when weather variables are conducive for *AFA* growth.

Probability-based models of photosynthetically-elevated pH as a function of *AFA* biomass (as measured by Chl-a) were developed for both Agency Lake and UKL (Kann and Smith 1999). A linear relationship between Chl-a and pH was demonstrated for both Agency and UKL (June-September). However for Agency Lake, lower Chl-a levels were associated with higher pH

values than in UKL. Probability plots for regression-based probability models of exceeding critical pH levels as a function of Chl-a concentration were also illustrative of the relationship between Chl-a and pH. At a Chl-a value of 100 ug/l there is an 18% probability of exceeding pH 9.5 for the UKL-wide mean model, while for the Agency Lake model there is a 40% probability of exceeding pH 9.5 at this same chlorophyll level. Given that Agency Lake has a mean depth of about 1.6 ft shallower (about 30%), than UKL, the light limitation mechanism can contribute to the greater than 2X difference in probability of exceeding pH 9.5 in Agency Lake (Kann and Smith 1999). In effect, the deeper water column in UKL is limiting pH reductions by lowering photosynthesis, since productivity is limited to the upper 3 ft of the water column, and also reducing pH by dilution. Conversely, a shallower lake can be expected to increase pH by concentrating photosynthesis into a shallower water column with greater availability of light (Welch and Burke 2001). Walker (2001) noted that the light reduction effect on *AFA* by lake levels in UKL was a significant factor related to pH and TP levels. These benefits are in addition to any dilution of wind-induced internal phosphorous loading that would occur with greater lake volume/depth, and a reduction in pH-induced internal phosphorus loading.

Initiation of *AFA* blooms has also been linked to inoculation of the water column by migrating vegetative cells from the sediment (Barbiero and Welch 1992). Migration of *AFA* "akinete", which are resting, vegetative stages, from the sediment contributed as much as eight percent of the observed water column increase in biomass of that species in Agency Lake in 1992 (Barbiero and Kann 1994). Although the trigger that causes migration is not well understood, these authors suggested that a threshold for light reaching the sediment may be more important than temperature. A deeper water column during the spring may delay the initiation of the first *AFA* bloom through reductions in light intensity at the bottom (Welch and Burke 2001; Walker 2001).

Upper Klamath Lake: External Phosphorus Loading

Phosphorus is of particular concern in UKL due to its role in limiting *AFA* productivity and biomass, which in turn influences water quality conditions affecting fishes, particularly high pH and severe diel swings in DO. Cyanobacterial blooms are associated with shallow lakes where phosphorous concentrations exceed 50-100 ppb (Sas 1989 cited by Walker 2001). Parameters that determine phosphorus concentrations in UKL include: inflow concentrations; inflow water volume; internally regenerated phosphorus from sediments, termed internal loading; and lake volume (Welch and Burke 2001; Walker 2001).

Despite high background phosphorus levels in upper Klamath River Basin tributaries and springs (Kann and Walker 1999; Rykbost 1999, Walker 2001), data exists from several studies to indicate that phosphorous loading and concentrations are elevated substantially above these background levels (Miller and Tash 1967; USACE 1982; USBR 1993a, 1993b; USGS 2000; USGS Water Resources Data 1992-1997; Kann and Walker 1999; Welch and Burke 2001; Walker 2001). One of the earliest nutrient loading studies (Miller and Tash 1967) indicated that, despite accounting for only 12% of the water inflow, direct agricultural input from pumps and canals accounts for 31% of the annual external total phosphorus budget. Other studies show that drained and diked wetlands consistently pump effluent containing 2-10X the phosphorus concentration of tributary inflows (USBR 1993a, 1993b), and that nitrogen and phosphorus are liberated from drained

wetland areas, leach into adjacent ditches, and are subsequently pumped to the lake or its tributaries (Snyder and Morace 1997). Coupled with the considerable but diffuse non-point contribution stemming from pumping from drained wetland, flood-plain grazing, flood irrigation, erosion of uplands, and channel degradation, the TP (total phosphorous) input from anthropogenic sources likely accounts for a far greater percentage than that indicated by the 31% contributed due to direct pumping alone. Gearheart et al. (1995) estimated that over 50% of the annual TP load from the watershed could be reduced with management practices, and Anderson (1998) likewise estimated that in-lake TP concentration could be reduced by utilizing watershed management strategies. Walker (1995) also estimates that an increase in Agency Lake inflow phosphorus concentration from 81 to 144 ug/l (40%) is an estimate of the anthropogenic impact.

The Williamson River and Wood River together accounted for 67% (48% and 19%, respectively) of the 1992-1998 total phosphorus load; springs and ungauged tributaries contributed another 10%. Precipitation, Sevenmile Canal and agricultural pumping accounted for the remaining 23% (Kann and Walker 1999). Unlike water contribution, where Wood River, Sevenmile Canal, and Pumps contribute 25% of the water load, these same sources contributed 39% of the average annual TP load. In contrast, springs contributed 16% of the water input, but contributed only 10% of the TP load. This appears to be partially due to the consistently higher volume weighted TP concentration occurring in the pump effluent, and Wood River and Sevenmile Canal systems.

The estimate of anthropogenic contribution of TP loading for all seven water years is 40% with a range of 36 to 45% for individual years. These values are very similar to the 40% anthropogenic TP contribution estimated by Walker (1995) for Agency Lake.

TP loads during the 1992 and 1994 drought years were 62% of the 1992-1998 average. The 1993 water year is of note because while flow was 108% of the 7-year average, TP load was 114% of the average. Other years (with the exception of 1996) tended to have percentage of average TP loads lower than their respective percent of average water inputs. It may be that during several low water years (e.g., 1991 and 1992), watershed sources of TP accumulate, and are then flushed into the lake during the next high flow year. Moreover, the volume weighted TP concentration of the Sprague River in 1993 is higher than any other year, indicating additional watershed contributions of TP. Because the Sprague River watershed is impacted by wetland and riparian loss, flood-plain grazing, agricultural and forestry practices, and channel degradation, it would be prone to TP export, especially during major runoff events.

An estimate of the particulate phosphorus (PP) load was taken as the TP load minus the "SRP" (soluble reactive phosphorus) load. These data clearly show an increase in the loading of PP during high runoff events for the Williamson and Sprague Rivers. During these high flow events, which typically occur from January-May, PP can increase to 60% of the TP load, compared to less than 5% during summer low flow periods. There are also noticeable spikes of PP load occurring in the Wood River and Sevenmile Canal systems, but they are not limited to high runoff periods. This pattern could be consistent with flood irrigation practices that would tend to be pulsed in nature, and where overland runoff could increase the proportion of particulates. The increase in PP loading is indicative of degraded watershed conditions. In a healthier watershed (e.g., intact riparian areas and flood plains) the concentration should tend to decrease at high flows through

dilution, and particulate loading should only increase slightly (Kann and Walker 1999).

TP levels are high in UKL sediments and in some receiving waters (Gearheart et al. 1995; Anderson 1998). TP enters UKL from a variety of sources including ground water which can have naturally high TP levels in the upper Basin. Agriculture has been identified as a major TP source in the upper Klamath Basin, especially from drained wetlands (Snyder and Morace 1997). Gearheart et al. (1995) estimated that TP loading in the UKL watershed is about equally divided between agriculture and forest land uses, being 38% and 36%, respectively. TP concentrations in UKL tributaries are correlated to runoff, suggesting that erosion is the primary causative agent (Gearheart et al. 1995; Williams 1998). TP levels are often correlated with turbidity or total suspended solids because phosphorous is often bound to small-sized particles. The USGS did a study of nutrient loading in the Williamson and Sprague River basins in 1992 and 1993 to identify land-use-specific nutrient loading (Williams 1999). The study found that turbidity in the upper Sprague River was highest in the North Fork and possibly in the area downstream from Beatty. The area upstream from Beatty was a significant source of nitrogen (N). Results of nutrient loading by different land uses was inconclusive because of the complex land-use mosaic; however, results did suggest that TP and N from forest lands are not insignificant (Williams 1999). A study by Anderson (1998) modeled TP reductions for various land management and restoration options. He found that tributary wetland restoration and riparian fencing were the most cost effective restoration efforts. Walker (2001) showed a relationship between increased in TP in UKL and external anthropogenic inputs. He determined that a 30-50% load reduction was necessary to meet water quality criteria established by DEQ.

Upper Klamath Lake: Internal Phosphorus Loading

Nutrient loading studies show that the largest flux of phosphorus to UKL during the summer comes from internal sources ((Barbiero and Kann 1994; Laenen and LeTourneau 1996; Kann 1998; Kann and Walker 1999; Welch and Burke 2001; Walker 2001). Lake outflow TP load tends to increase during high runoff events in the winter and spring, as well as during the summer period when inflow load is low. It is clear from this trend, and the increase in lake TP storage at a time when lake water storage is decreasing, that TP is being internally loaded from the sediments. These large net internal loading events are generally followed by a substantial decline, indicating a large sedimentation event. Such events coincide with *AFA* bloom crashes (Kann 1998). On average, external loading was 39% of the total loading to the lake, while internal loading was 61%. On an annual basis there tends to be a net retention of TP in the lake due to the significant sedimentation events from *AFA* bloom crashes and the likely settling of PP during high runoff, e.g., annual average retention is 25 metric tons. However, it is evident from the negative retention, positive internal loading, during the May through September period that internal loading is a significant source of phosphorus to the lake.

One important mechanism for internal loading of phosphorus in shallow productive lakes is photosynthetically-elevated pH (Welch 1992; Sondergaard 1988; Jacoby et al. 1982; Welch and Burke 2001; Walker 2001). Elevated pH can increase phosphorus flux to the water column by solublizing iron-bound phosphorus in both bottom and re-suspended sediments as high pH causes increased competition between hydroxyl ions and phosphate ions, decreasing the sorption of iron-

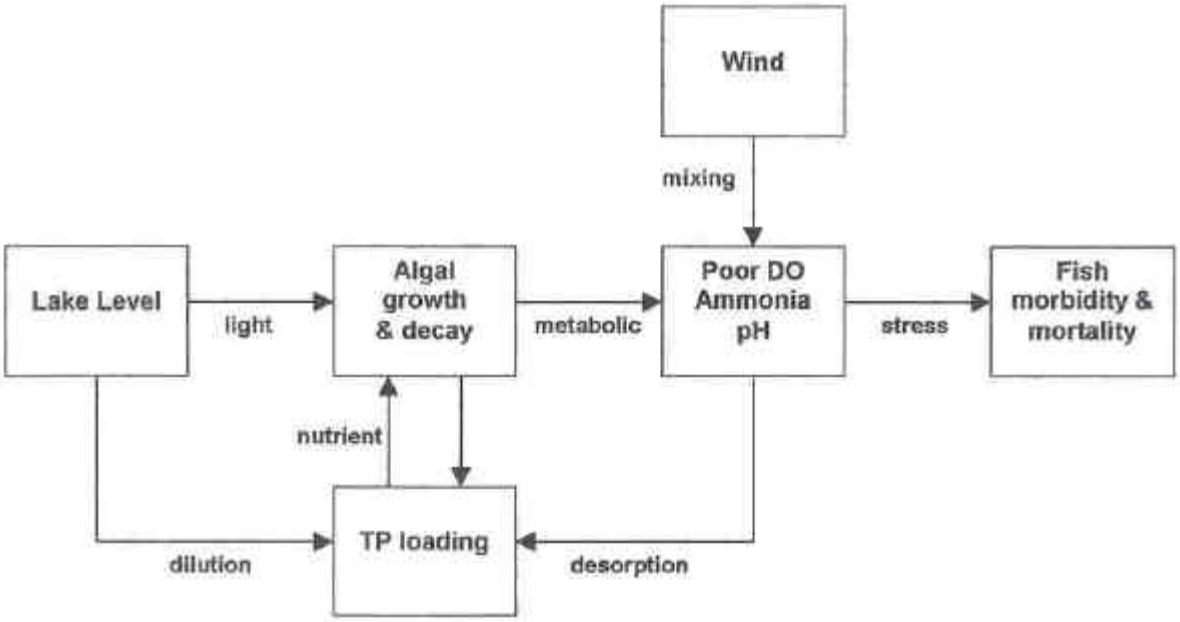

Figure 1. Main causal relationships determining the impact of lake level on fish condition and survival.

bound phosphate. Evidence for this exists in UKL where it was shown that the phosphorus associated with hydrated iron oxides in the sediment was the principal source of phosphorus to the overlying water, and that iron-phosphorus fractions decreased from May to June and July (Wildung et al. 1977). Moreover, Kann (1998) showed a direct relationship between pH and net internal loading in UKL. A similar mechanism occurs with phosphorus adsorbed by aluminum oxides (Jassby and Goldman 1995).

In addition, the probability of achieving increased internal loading rates increases with pH, and it appears that about pH 9.3 is the level at which the probability of internal loading sharply increases (Kann 1998). Empirical evidence from UKL along with supportive evidence from other lakes indicates that as the *AFA* bloom progresses and elevated pH increases, the flux of phosphorus from the sediment to the water column increases. Increased water column phosphorus promotes *AFA* biomass which leads to increased pH, setting up a positive feedback loop (Kann 1998) (Figure 1, from Welch and Burke 2001). Low lake volume can accelerate this feedback mechanism through two mechanisms. First, at low lake levels the lower water volume does not dilute the phosphorus influx to the extent that a higher volume would, which is especially significant when internal loading is high. Secondly, as water depth decreases, resuspension of bottom sediments by wind action occurs more frequently and the quantity of sediments resuspended also tends to be greater. Such resuspension events are significant because while high pH solubilizes phosphorus and makes it available for *AFA* growth, wind resuspension increases sediment contact with the water column which optimizes the release of iron-bond phosphorus (Sondergaard 1988). As such, higher lake volume would be expected to decrease the phosphorus available for *AFA* growth by dilution and decreased frequency and magnitude of resuspension.

Wood et al. (1996) stated that a critical set of circumstances is required to initiate internal loading of phosphorus; lake level is only one of those circumstances, and its relative importance is unknown. The authors concluded that the phosphorus dataset analyzed in this study was not sufficient to quantify the contributions of wind magnitude, fetch, high pH, and lake level (four of the most easily identified relevant variables) to the internal loading of phosphorus.

However, new modeling by Welch and Burke (2001) that assessed the effects lake levels would have on pH, indicated that by keeping the lake above a critical maximum could reduce the number of days pH levels would exceed pH 10. They found that by setting the minimum elevation at 4142 ft would reduce days with pH >10 by 64%, at 4141 ft by 51%, and at 4140 ft a pH >9.5 by 27%; all relative to historic conditions. These effects could bring significant water quality improvements to UKL and reduce the probability of fish kills and improve sucker survival and recovery.

A low lake level could also enhance internal loading by increasing wind-induced, bottom shear stress. Theoretical estimates based on UKL bathymetry indicated that the bottom shear stress created by a 10 mph wind at lake elevations as low as 4137 ft could be very effective at resuspending sediment (Laenen and LeTourneau 1996). The same analysis indicated that the areally-weighted, bottom shear stress of 4140 ft elevation would be about one-half that at 4137ft, but could still be at a value that could effectively resuspend sediment. Subsequent analysis indicated that bottom shear stress decreases rapidly for lake elevations above 4140 ft. Similar results were obtained in modeling by Philip Williams & Associates (2001).

Rather than combining the seasonal (June-August) total phosphorus data set for each year as the Klamath Tribes had done, Wood et al. (1996) analyzed the data on a month by month basis. They also plotted the data set over the growing season by station. Phosphorus concentration was, at times, highly variable around the lake. They determined that there was an apparent relation between total phosphorus concentration and lake level during June. Further, total phosphorus concentration in June was correlated with Chl-a concentration in June, suggesting that the strength of the first bloom is influenced by phosphorus concentration. External loading from spring runoff could be an important factor in determining the phosphorus concentration in the lake at that time.

Role of pH in Upper Klamath Lake Water Quality

Levels of pH are an important water quality parameter in UKL because they affect aquatic organisms, including suckers, and have been shown to mediate internal loading of phosphorus. As discussed above, pH values >9.55 caused a loss of equilibrium in juvenile SNS; swimming performance of larval LRS was reduced at pH of 10.0, and values >10.3 proved lethal to larval and juvenile SNS and LRS (Falter and Cech 1991; Saiki et al. 1999; Meyer et al. 2000).

During rapid growth, *AFA* can reach "bloom" proportions. If the bloom is large enough, and mixing/reaeration are minimal, such as occurs when there is no or little wind, pH will increase because the rate of carbon-dioxide fixation through photosynthesis exceeds the rate of input from the atmosphere, shifting the equilibrium between free carbon-dioxide and carbonate ions in the water. Thus, pH levels are related to photosynthesis and acutely toxic levels of pH are common

during afternoons in hypereutrophic lakes, including UKL

Kann and Smith (1999) examined the relationship between Chl-a and pH for UK and Agency lakes. Their working hypothesis was that since high pH was a result of *AFA* photosynthesis, Chl-a and pH, should be correlated. Chl-a is used as an index for *AFA* biomass, because Chl-a and *AFA* biomass are also correlated.

Kann and Smith (1999) found that Chl-a and pH in UKL were highly correlated. Because the response of pH to the intensity of *AFA* photosynthesis is rapid, the use of data from individual dates, as well as from monthly or seasonal means is valid. Kann and Smith (1999) developed two separate statistical models between Chl-a and pH. The regression model developed between lake-wide mean values of Chl-a and pH in UKL for the June-September period yielded an r-squared value of 0.72. This value increased to 0.95 when the model was developed from UKL June Chl-a and pH. The year with the highest June Chl-a (1992) also had the highest June median pH (about 9.9) and the lowest lake level (Kann and Smith 1999).

The effect of diluting the internal P loading flux from sediments by maintaining higher lake elevations was predicted during 1990-1998 spring-summer periods with a mass balance TP model. That effect on lake TP concentration was used to predict the effect on Chl-a concentration and pH. For example, the days that pH could be expected to exceed pH 10 decreased by 64% if the minimum level was set at 4,142 ft, 51% at 4,141 ft, and 35% at 4,140. (Welch and Burke 2001).
Wood et al. (1996), applying univariant analyses, concluded that there was no evidence for a relation between Chl-a and lake level on the basis of seasonal distribution of data or a summary seasonal statistic. USGS updated the data analyses from their earlier report (1990-1999) and the inclusion of five more years of data did not demonstrate a discernable relationship. This finding was not unexpected since Chl-a values are likely dependent on complex set of parameters that may not necessarily be lake-level dependent, such as weather. New analyses by Welch and Burke (2001) have predicted, using three different models (Oskam, Michaelis-Menton, and Steele), that maximum Chl-a values at a mean depth of 1.5 m (5 ft) could be more than twice as great as it would be at 2.7 m (9 ft).

June was an important month to examine Chl-a and pH because the first *AFA* bloom of the year usually started in late May, June, or early July. In June it was found that the concentration of Chl-a and the frequency of very high pH values were lower at higher lake levels, and that the start of the first bloom was delayed at higher lake levels (Wood et al. 1996; USGS 2000, unpub. data; Welch and Burke 2001). Because of the relation between pH and *AFA* growth, the dependence of pH on lake level and degree-days parallels to some extent the dependence of Chl-a on lake level and degree-days. Therefore it appears that lower-lake levels may increase the probability of an earlier bloom and consequently an earlier rise in pH (Welch and Burke 2001).

Kann and Smith (1999) suggested that efforts to improve water quality in UKL and Agency Lake might be focused on reducing *AFA* productivity to a point that pH levels can be tolerated by the fish community. The results of their analyses showed that a 50% reduction in Chl-a levels, from 200 to 100 mg/l, would result in a 45% reduction in the probability of exceeding a pH of 9.5.

Modeling by Welch and Burker (2001), mentioned above, found similar reductions. Such a reduction may be possible if anthropogenic nutrient inputs, especially TP, to the lake are reduced 30-50% (Walker 2001). Walker (2001) points out that this could be achieved since an 8% decrease in TP was observed in the past decade, likely as a result of watershed and wetland restoration efforts.

Role of Water Temperature in Upper Klamath Lake Water Quality

Lake temperature is an important physical parameter affected by volume and depth. For example, shallow lakes exhibit more rapid heating and cooling than adjacent deep lakes, and require less solar radiation in spring to raise the temperature of surface waters (Goldman and Horne 1983). Because *AFA* bloom initiation is often linked to temperature increases in the spring when temperatures reach 15-17 E C, lake volume has the potential to affect the timing of late-spring early-summer blooms. At low lake volume, warm late-spring and early-summer air temperatures can translate more directly to warmer water temperatures which in turn can cause early bloom development and faster *AFA* growth rates. Because maximum UKL elevations also occur during cooler (and presumably wetter) late winter and spring conditions, it is not possible to determine statistically the relative effects of volume and degree-days.

Wood et al. (1996) suggested that the time from April 1 to the start of blooms in the spring was determined more by water temperature, specifically by degree-days since April 1, than by lake level. Nevertheless, the year with the earliest large bloom was 1992 (June), which was the year with the lowest spring-time lake level throughout the 1990-1999 monitoring program. The bloom also began early in 1994, but was slower to reach a lower maximum. The latest documented *AFA* bloom of significant magnitude in UKL occurred in September 1991, but Chl-a still reached 280 ug/l.

Wood et al. (1996) showed that June Chl-a values in UKL were directly related to degree-days after April 1, implying that a longer exposure to higher temperature would produce more biomass. Kann (1998) further investigated the hypothesis of temperature control of bloom timing with a longer data set (1990-1996) and found that the relationship between time when the *AFA* reached a given biomass and degree-days since April 1 was relatively strong. The delayed bloom of 1991 coincided with the fewest degree-days during April 1-May 15 and the 1992 bloom experienced the most degree-days. Also, Kann (1988) showed a positive relationship between the time for a given biomass and the time when the first 7 consecutive day air temperatures reached 15E C. Kann (1998) showed that lake volume, or depth, may also influence spring bloom, suggesting that higher lake levels may reduce bloom development.

Wood et al. (1996) compared Klamath Falls air temperatures and UKL water temperatures from 1992-1994. They observed that air temperature exerts a strong influence on lake temperature because daily to weekly fluctuations in the1-m-depth water temperature records parallel the air temperature, with a lag time of a few days. This does not mean that air temperature determines the absolute temperature in the lake; the absolute temperature is determined by the overall heat budget, of which air temperature is only one component. Because lake elevations during the late-spring/early-summer only vary about one foot between high and low elevation years, water

elevation is not likely to be an important factor affecting water temperature at that time of year. However, during the late-summer when the lake elevation difference between a high and low elevation year can be 4-5 ft, lake elevation may be a significant factor affecting temperature with a lag time to equilibrium as much as 10 days. It has also been surmised that there may be a greater diel temperature fluctuation at a lower lake elevation (J. Kann, Aquatic Ecosystem Sciences, pers. comm.).

Wood et al. (1996) investigated the dependence of water quality variables on air temperature and cloud cover. They concluded that year-to-year differences in the timing of the first bloom are related to year-to-year differences in the number of degree-days between April 1 and May 15, such that the bloom occurs earlier at a higher number of degree-days. The data also supported the hypothesis that year-to-year differences in June chlorophyll-a concentration are related to year-to-year differences in the number of degree-days between April 1 and May 15, such that concentrations are higher at a higher number of degree-days. The cloud cover index corresponds well with the number of degree-days, with a higher number of degree-days being associated with more sunshine and a higher index. Lake level and climate variables likely act concurrently or in conjunction with each other to affect algal biomass. For example, results from a heat budget model (Welch and Burke 2001) show that lake level does interact with temperature, producing longer lag time to reach equilibrium water temperature at higher lake level. Additionally Welch and Burke (2001) concluded that temperature during spring affects *AFA* and other phytoplankton growth rates and how fast maximum biomass is reached, but the lake level influence on underwater light has a greater effect on the maximum biomass that can eventually develop.

Role of Dissolved Oxygen in Upper Klamath Lake Water Quality

As discussed above, DO concentrations < 2.5 mg/l can be lethal to suckers (Saiki et al. 1999). Low DO levels in UKL and in other Project waters can be expected during the summer when warm temperatures elevate bio-chemical processes, and in winter when ice cover stops atmospheric reaeration. Welch and Burke (2001) state that DO levels in UKL are primarily dependent on four factors: (1) magnitude of senescing *AFA* and algae bloom (demanding more DO than is produced by photosynthesis); (2) ratio of bottom sediment (source of DO demand) to lake volume, which can be approximated by surface area: volume ratio (which increases from 0.1 at 4143 ft to 0.25 at 4137 ft); (3) extent of wind-driven reaeration; and (4) temperature (which determines rates of bio-chemical DO utilization). They cite modeling by Livingstone and Imboden that indicate the increase in DO depletion near the bottom of lakes suffering from eutrophication is largely due to increases in sediment area per unit volume, since water column demand is rather constant among different lakes.

The potential for low DO concentration increases later in the growing season (July-September) when *AFA* blooms have crashed and considerable organic matter has accumulated in the sediments. During this same period, increased water temperature increases water column DO depletion rates as decomposition and respiration take place at a faster rate, and DO concentrations in the water column tend to be lower because oxygen solubility decreases as water temperature increases. In addition, the ratio of lake volume to sediment surface area decreases as lake volume decreases (discussed above), and as this ratio decreases the depletion rate of DO in the water column

increases because the lower water volume holds less DO relative to the biochemical DO demand of the sediments.

The inverse relationship between mean depth and the volume-based DO depletion rate has been demonstrated under ice in numerous lakes, and the greatest depletion rates occur in shallow hypereutrophic lakes, such as UKL (Mathias and Barica 1980 and citations in Welch and Burke 2001). In shallow lakes like UKL atmospheric reaeration can increase water column DO concentrations. However, the depletion rate is further increased when metabolic demands, e.g. of bacteria and macro-organisms such as fish, are maximized by high water temperatures and increased resuspension of sediments with a DO demand occurs.

Wood et al. (1996) analyzed the 1990-1994 UKL DO data using univariate analyses (single parameter) and concluded that the data are not sufficient to distinguish the relative importance of the various processes and the possible artifacts of data collection that determined the measured DO concentrations. Because very different DO concentrations occurred at similar lake levels, it is most likely that temporal trends were determined primarily by seasonal factors, such as the *AFA* bloom/decay cycle, water column stability, and wind speeds; July -August water temperature control of DO saturation is not as important as these factors since it is rather constant from year to year. Addition of five more years of data (1995-1999) to the analysis did not result in a discernable DO and lake-level relationship (Wood, unpub. data).

It should not be surprising that univariate analyses did not find a relationship between lake levels and DO levels since a complex set of physical, chemical, and biological factors are likely involved, with lake levels being only one of these. DO levels should be related to rates of reaeration with in turn are dependent on wind speed which mixes the water column bringing DO from the surface into deeper depths. Welch and Burke (2001) showed that water column stability and wind speed are inversely correlated, such that stability decreases at higher wind speed. This likely explains why 1992 and 1994, both windy years (as measured at Klamath Falls), had no fish kills even though DO levels were relatively low (Welch and Burke 2001). Further, modeling indicated that in UKL, stability is more dependent on wind speed than depth, thus finding a significant relationship between lake levels and DO is confounded by the dominant effects of wind (Welch and Burke 2001).

Water Quality in Upper Klamath Lake During Ice-Cover Conditions

It is important to note that the winter, under-ice DO concentrations can be low given UKL's high *AFA* biomass production and large sediment DO demand. When there is sufficient light penetration for photosynthesis to occur, the production of DO below the ice might be adequate to offset the depletion occurring from sediment demand and respiration. However a cover of snow reflects much of the light and snow depth over ice is an important factor determining the DO depletion rate.

UKL data during ice-cover conditions from 1988, 1989 and 1993 indicated DO depletion at or near bottom depths (Klamath Tribes unpub. data). This depletion will migrate up into the water column as the season progresses due to the prevention of atmospheric oxygen diffusion into the

water by ice-cover. The lower the light penetration the faster the depletion will occur. DO concentrations from several dates and sites were highest at the surface and lowest at the deepest measured depth. DO values <5 mg/l were commonly observed at depths >2 ft and concentrations of <1 mg/l were documented at several sites during 1988, 1989, and 1993 (Klamath Tribes unpub. data). There are too few data to determine the areal extent of this depletion and the full magnitude of depletion, but it is likely to be present throughout the lake except where aeration is occurring and is likely lower than measured at the few stations where measurements were made.

Lake volume (elevation) under-ice conditions influences the rate of DO depletion. For example, a change in lake elevation from 4140 to 4137 ft results in a 30% reduction in mean water column depth. With a larger sediment to volume ratio at lower lake elevations, DO depletion will occur faster than at higher lake elevations. Therefore, there is a higher probability of low DO at lower elevations. Under-ice DO concentrations <5 mg/l were measured at elevations 4139.5 (1993), 4140.9 (1988), 4141.1 (1989) and 4141.7 (1988). Because low DO occurred at a wide range of elevations, fish may be even more vulnerable to poor water quality during the winter when ice-cover conditions prevent air-water diffusion.

Welch and Burke (2001) estimated what DO levels in UKL would be under ice-cover condition using SOD values (1.5-3.0 gm DO/m2/day at 20 C) from USGS, and assuming Q10 = 2, and found that DO levels would be adverse to suckers after 60 days of ice cover or less. To reduce the risk of catastrophic, winter fish kills, they recommended that UKL end of season levels should not go below 4140 ft and be brought up quickly. Because of winter conditions in the Klamath Basin, under ice hypoxia appears to be a significant risk to suckers in UKL and other Project lakes and reservoirs if winter lake levels are not sufficiently high to reduce this risk.

Another potentially important consideration regarding winter water quality as it affects suckers is un-ionized ammonia. The toxic effects of un-ionized ammonia were discussed above. Un-ionized ammonia becomes more toxic at lower temperatures and lower pH conditions (Loftus, R2 Resource Consultants. pers. comm). The concern will be what happens when pH and temperature decline in UKL in the fall when total ammonia is still high (as in 1996 –1998) (Loftus, R2, pers. comm). Currently no data are available on un-ionized ammonia levels in UKL or other Project lakes and reservoirs in winter and potential effects. However, un-ionized ammonia may be a risk to suckers, especially if winter lake levels are not sufficiently high to dilute ammonia to non-toxic levels.

Effects of Hanks Marsh and Other Marshes on UKL Water Quality

As described in section 2.2, wetlands play a crucial part in the ecology of UKL today; however, in the past, prior to widespread wetland loss and degradation, they were even more significant. The total number of acres of wetlands historically affecting UKL is unknown, but must have been over 150,000 acres (Akins 1970). These wetlands played a critical role in macro-nutrient dynamics, especially phosphorous, and in cycling of particulate and dissolved organics. It is likely that these wetlands would have been a net sink for phosphorus and nitrogen, and a source for organics. A number of authors have pointed out (e.g., Phinney et al. 1959; Gearheart et al. 1995), the role collodial humic substances, originating from wetlands, may have had on regulating primary

production. Although not fully understood, it appears that humics in association with low pH, can reduce *AFA* blooms, and might have been one factor responsible for the absence or near absence of *AFA* until the last century.

An investigation of the physical, chemical and biological characteristics of Hanks Marsh was conducted by the National Biological Service from 1992 to 1994 (Forbes et al. 1998). This study provides the most detailed information of water quality in littoral wetlands in UKL to date and allows for comparison with water quality conditions in offshore areas.

Results of this study are for the most part consistent with what is known about physical and chemical conditions in inshore areas. Several parameters formed a horizontal gradient as distance from the shore zone increased. These differences are related to the dominance by emergent vegetation and resulting sheltered conditions that lead to hydrologic isolation. Conductivity, dissolved solids, pH, phosphate, and nitrate ions, and total phosphorus formed a horizontal gradient of increasing concentrations.

AFA blooms that are so prevalent in open water areas were not observed in the marsh. Although the exact mechanisms are not well understood, the relationship between humate content and inhibition of many planktonic algae species has been established on both a local and national level (Phinney et al. 1959; Perdue et al. 1981; Wetzel 1983). Other contributing factors include light limitation and low pH.

Most parameters exhibited substantial seasonal variations. On a study-wide basis, however, phosphorus, inorganic nitrogen, and Chl-a levels were more similar to lake water than to levels found in selected tributaries. The results of this study do not address the flux of material between the inshore and offshore zones. Some of the data suggest, however, that offshore conditions influence the outer areas of Hanks Marsh. Conversely, processes within the marsh may form water quality gradients that extend offshore. Hazel (1969) documented a hydrogen ion gradient extending into the lake from Hanks Marsh.

The physical and chemical characteristics of large littoral marshes around UKL may historically have played an important role in regulating *AFA* biomass and other characteristics of the system. Littoral wetlands have been drastically reduced in size due to agricultural reclamation. Since 1940, 23,000 acres have been diked and drained in UKL (Carlson 1993), with total losses of about 50% lost since development began over 100 years ago. Approximately 15,000 of these acres are in the process of being restored to wetlands; however, they are not open to the lake.

Upper Klamath Lake Water Quality: Summary

By the late 1800s, UKL was apparently highly productive and may have experienced occasional fish kills. With increased human-induced changes in the watershed as a result of agriculture and grazing, nutrient input to the lake increased. Loss of wetlands, especially those adjacent to the lake was likely also a factor affecting nutrients. By the mid-1900s the lake had reached a hypereutrophic status as a result of establishment of dense blooms of the cyanobacterium *Aphanizomenon flos-aquae* (Eilers et al 2001; Welch and Burke 2001; Walker 2001)).

Shallow depths in UKL promote wind-shear stress and resuspension of sediments. The shallow depths also increase a *AFA*-pH-phosphorous-*AFA* feedback loop increasing internal loading of phosphorus and ensuring that *AFA* growth is not nutrient limited. Shallow depths also reduce effects of light limitation, which occurs in UKL at depths as shallow as 3 ft. Consequently *AFA* blooms reach extreme levels of 200,000 cells/ml and Chl-a levels of >0.2 mg/l. *AFA* bloom and decay cycles greatly affect water quality in UKL from June to November. DO, pH, and un-ionized ammonia are all affected and regularly reach levels considered stressful or acutely toxic to fish (Loftus 2001; Welch and Burke 2001). Water quality, especially low DO are considered to be the main causative factors of repeated fish kills that occurred in the mid-1990s (Perkins et al. 2000b). Low DO levels are primarily the result of high sediment DO demand. During high sediment DO demand conditions increased water column stability and calm winds probably serve to exacerbate problems by reducing aeration and promoting release of un-ionized ammonia (Welch and Burke 2001). The three fish kills in the 1990s were the worst on record, suggesting that water quality may be continuing to decline.

Recent analysis of data surrounding the UKL fish kills in 1995-1997 have shown the dependence of low DO conditions on water column stability resulting from low wind speed, regardless of depth, and the magnitude of bloom decline (Perkins et al 2000b; Reiser et al. 2001; Welch and Burke 2001). As a result, the earlier relationships determined between lake levels and minimum DO levels observed by Jassby and Goldman (1995) and analyses by the Klamath Tribe do not persist with additional data. While the source of DO demand (ultimate cause) leading to low DO conditions is the magnitude of *AFA*/algal blooms, which is directly linked to TP concentration and light availability, and these factors are directly linked to lake level, lake level should only indirectly be linked to DO conditions (Perkins et al 2000b; Walker 2001; Welch and Burke 2001). However, wind speed determines water column stability, which determines the degree of reaeration of the water column, so wind speed would have to remain relatively constant during summers for the data to show a univariate relationship between lake level and minimum DO (Welch and Burke 2001). Because wind speed on an annual basis has not been constant (Welch and Burke 2001), such a simple relationship should not be expected. Nevertheless, by maintaining higher lake levels, TP, light and algal biomass (DO demand) should be lower and a worst-case situation of a low wind-speed summer combined with low lake level may be avoided (Welch and Burke 2001). Had wind speeds been low during 1992, the year with the lowest lake level and largest spring *AFA* bloom, DO conditions would probably have been worse than even the low values observed, and a significant fish kill would likely have occurred.

Restoration and other beneficial actions in the watershed may reduce external nutrient loading to a point where the *AFA*-pH-phosphorous feedback loop might not be effective (Walker 2001). However over the short-term, higher lake levels appear to be the only means of reducing the frequency and magnitude of the adverse water quality conditions that cause fish kills (Welch and Burke 2001). Higher lake levels may serve to improve water quality by a variety of potential mechanisms, for example: (1) reducing wind resuspension of bottom sediments thus reducing internal nutrient loading, and thus reducing *AFA* productivity; (2) reducing mean water-column light intensities thus reducing *AFA* productivity; (3) diluting pH, thus reducing the effect of the *AFA*-pH-phosphorous feedback loop; (4) diluting phosphorus and other nutrients, thus reducing *AFA* productivity; (5) increasing the lake volume to sediment area, thus decreasing the effect of

sediment DO demand on water-column DO, both during the summer when metabolic processes are high, and in winter, under ice-cover conditions when aeration ceases. Effects of lake depth on primary production is well documented, even for shallow lakes (e.g., Reynolds 1986; Scheffer 1998; Welch and Burke 2001, and references therein).

Vogel et al. (2001) and Horne (2001) propose that "lower" UKL lake levels would bring water quality benefits, especially higher DO levels. It is unclear what lake levels they consider necessary, and literature citations provided supporting this position are relative to two lakes that are much deeper on average than UKL. The central point of the Vogel et al. argument is that UKL suffers from low DO levels in summer because it is stratified. However, no supporting data from UKL are provided. The available data do not support this position, and instead indicate that UKL is mostly well mixed and, rather than becoming stratified in summer, undergoes periods of increased stability (Welch and Burke 2001; R2 Resource Consultants 2001). This distinction is not trivial since in truly stratified lakes reaeration of bottom waters by wind mixing is much reduced by water layers developed by distinct density differences. Welch and Burke (2001) conclude that a temporary lack of wind is the primary factor responsible for summer periods of increased water column stability (and resultant lack of mixing and reaeration) in UKL, which are responsible for periodic hypoxic conditions in the water column that lead to sucker stress and die-offs.

Welch and Burke (2001, figure 4-10) show that wind speed is inversely correlated with RTRM ("Relative Thermal Resistance to Mixing"; a water column stability index that is based on density differences) such that high RTRM occurs when winds speeds are low. During the fish kill years (1995, 1996, and 1997), RTRM was high and July-August maximum wind speeds (as measured at Klamath Falls, the nearest meteorological station with wind measurements) were low. In 1992 and 1994, when median August UKL levels were lowest, wind speeds were high and, consequently, RTRM was low. Had the reverse been the case, Welch and Burke (2001) argue that DO conditions in 1992 and 1994, which were adverse, could have been even worse. Since winds cannot be managed, summer and early fall lake levels in UKL need to be managed near the higher pre-project levels to reduce risk of catastrophic fish kills.

During the comment period following the release of the draft BO, the Service received a number of comments regarding the Vogel et al. (2001) report, including those from USGS (2001), Klamath Tribes (2001), R2 Resource Consultants (2001) and G. Welch (2001). None of these comments supported the assertion made by Vogel et al. (2001) regarding potential water quality benefits of reducing water levels in UKL.

The Service concludes that the pre-project minimum lake levels of 4140 ft (and similar minimum lake levels presented in the RPA) are necessary to protect suckers from adverse water quality and are based on the best available science. In reaching this conclusion, the Service recognizes that a relationship between water quality and lake levels in UKL that is statistically significant, for example at a 95% confidence level, has not been established However, based on our analysis of the best available scientific data, we conclude that minimum UKL elevations approximating those experienced pre-project are supported. The dominant factors controlling water quality in UKL are weather and climate which are not controllable, whereas lake levels can be managed. Considering

the high risk that adverse water quality poses to sucker survival, managing UKL using pre-project lake levels with a minimum elevation of about 4140 ft is considered by the Service to be necessary to ensure sucker survival and recovery.

Other Miscellaneous Ongoing Effects to Endangered Suckers

Effects of Ongoing Watershed and Stream Alterations on Water Quality and Quantity

Watershed and stream alterations can affect sucker habitat and water quantity and quality. Hydrologic alterations can directly affect spawning habitat. The preferred sucker spawning substrate is gravel, and eggs are broadcast and will therefore settle among the stones. Hydrologic changes that alter normal bedload movement and scour and fill patterns can excavate or bury eggs, exposing them to stream flow, and trapping or crushing eggs or fry. Increasing levels of fine sediments affects developing embryos by filling interstitial spaces within stream substrate, reducing or eliminating water flow through the substrate, cutting off the supply of oxygen, causing waste products to build up, and may be sufficient to reduce or eliminate the ability of larvae to emerge from the substrate. Hydrologic and sediment regimes can be altered by vegetation removal, site disturbance, and soil compaction associated with timber harvest and grazing.

Degraded stream channels are often a result of higher peak flows and increased sediment loads resulting from watershed alterations. Streams may become incised, no longer allow over-bank flooding, and thus all energy must be dissipated with the channel resulting in increased channel erosion. Also, less water is stored in the floodplain resulting in decreased baseflows.

One of the most damaging watershed alterations is compaction of soils, causing faster runoff of surface water such as along road ditches. Roads, because they consist of compacted and impervious soils, act as extensions of the drainage system by redirecting subsurface water to the surface and routing it into stream channels more quickly. This results in increased storm flows, as discussed below, and reduced base flows in streams. Baseflows may also be reduced when fire suppression leads to higher densities of trees. Reduction of baseflows would contribute to reduced water quality in sucker habitat. Risley and Laenen (1999) noted changes in flows in the Williamson and Sprague rivers when pre-1950 flow data were compared to more recent data. These data were insufficient to allow determination of what land-use was responsible for the change, but agriculture, forestry, and grazing are the major land-disturbing actions in the watershed.

Although temperatures in the Klamath Basin rarely if ever get sufficiently high to be lethal to suckers, they do affect suckers in a variety of ways, such as *AFA* blooms and associated changes in water quality, as discussed above. Locally, suckers may seek out areas of better water quality, where lower temperatures and higher DO concentrations occur during summer (Bond et al. 1968; Hazel 1969; Bienz and Ziller 1987; Buettner and Scoppettone 1990). High temperatures are also believed to be involved with heavy parasite loads on suckers and other fish such as in Clear Lake (Snyder-Conn, Service, pers. comm. 1999).

Although high temperatures can contribute to seasonally stressful water quality conditions, they

may also contribute to high sucker growth rates. Terwilliger et al. (2000) found that within the 15 to 24E C range of summer temperatures that juvenile suckers in UKL experienced in 1997, growth was fastest at the highest temperatures. This suggests that higher temperatures, and associated increased growth and available food, may benefit suckers as long as water quality conditions do not become overly stressful or lethal.

Oregon Department of Water Quality (ODEQ) has identified nearly 25 stream segments flowing into UKL as being temperature limited (ODEQ 1998). Groundwater entering streams, especially small streams, may be an important determinant of stream temperatures (Spence et al. 1996), or may provide localized thermal refuges. Where groundwater flows originate above the neutral zone, approximately 50-60 ft below the surface, groundwater temperatures will vary seasonally, as influenced by air temperature patterns (Spence et al. 1996). Groundwater recharge is reduced when soil interstitial spaces are lost or soil "pipes" fill owing to soil compaction.

Effects of Ongoing Forest Practices on Water Quality and Watershed Function

The Service assumes that forestry practices using accepted best management practices (BMPs) have minimal impacts to listed species, including suckers. However, it remains to be determined whether acceptable BMPs are being fully implemented in areas where they could affect suckers.

Timber management affects listed suckers through a variety of impacts or alterations to watershed structural conditions and functional capacity. The primary pathways for negative impacts are through alterations of stream temperature patterns, hydrologic and sediment regimes, and reduction of channel complexity as well as the structural features that maintain channel complexity. Potential adverse effects also include introduction of pollutants, e.g., fuels, fertilizers, pesticides, and herbicides, into watercourses while conducting harvest, site preparation, and stand maintenance activities.

Forests in the Klamath basin have been managed for timber production, with substantial activity in the 1925-1940 period, peaking at 800 million board feet. The current harvest is much less than this. Extensive harvesting, including partial cutting with overstory removal, clearcutting, and selective logging for old-growth pine occurred on private lands, and low intensity harvest occurrs on some of the U.S. Forest Service lands.

Past forest management activities in the Klamath River basin have temporarily reduced riparian vegetative cover and increased water temperature in some streams (Light et al. 1996; USFS 1994, 1995a,b, 1996, 1998). Sediment from existing roads continues to degrade stream habitat (Light et al. 1996). There was also a decrease in the numbers of pools in streams in the Basin (Lee et al. 1997). The watershed analysis reports, produced by Winema NF and Fremont NF, provide the most complete analyses of present conditions of watersheds and streams within the action area (USFS 1994, 1995a,b, 1996, 1997, 1998).

Private industrial forest lands in the UKL watershed comprise about 0.4 million acres. The Oregon Department of Forestry has implemented land management plans for State and private forest lands. Water protection rules have been adopted and apply to all public and private

commercial timber lands. Under these rules, operators submit a harvest plan and must obtain written approval from the State Forester before tree harvest within buffers that are delineated as the "Riparian Management Zone." The Service is unaware of any data on compliance with protection rules. However, ODEQ has recently reviewed the water protection rules and problems with compliancy with State water quality regulations. With full compliance it is assumed that aquatic ecosystems are adequately protected.

Timber harvest has the potential to affect stream temperatures primarily through reducing streamside canopy levels. The potential for riparian vegetation to mediate stream temperatures is greatest for small to intermediate size streams and diminishes as streams increase in size, lower in the floodplain (Spence et al. 1996). Generally, small and intermediate streams represent the majority of total aggregate stream length within a watershed (Chamberlin et al. 1991). Given these relationships, maintaining adequate canopy conditions on small and medium sized streams (including intermittent streams) is necessary to avoid altering natural temperature regimes. A reduction of stream shading is considered to be the major cause of increased stream temperatures in the upper Klamath Basin (S. Kirk, ODEQ, pers. comm.).

Timber harvest from upland areas exposes the soil surface to greater amounts of solar radiation than under forested conditions (Carlson and Groot 1997), elevating daytime temperatures of both air and soil (Fleming et al. 1998; Buckley et al. 1998; Morecroft et al. 1998), and increasing diurnal temperature fluctuations (Carlson and Groot 1997). Relationships between shallow source groundwater flows and air and soil temperatures indicate that harvest activities in upland areas may increase stream temperatures via increasing temperature of shallow groundwater inflows. Other pathways for harvest actions to influence stream temperature include changing the volume and timing of peak flows, elevating suspended sediment levels, and altering channel characteristics (Chamberlin et al. 1991; Spence et al. 1996; USDA and USDI 1998). Channel characteristics affect stream temperatures if the stream channel width /depth ratio is increased since more water surface is exposed to heating by air and sunlight. Also, reduced summer baseflows can lead to higher temperatures, since a smaller volume of water is more readily heated than a larger volume.

Forestry practices, especially road construction, are known to be major contributors to water quality impairment. Roads also affect stream flows by increasing storm runoff. Also, some railroad logging used stream channels as grades. Lee et al. (1997) found there was strong evidence that forestry has adversely impacted streams in this region. They found correlations showing that streams were adversely modified as a result of forestry practices. Additionally they noted an inverse relationship between the intensity of forestry practices, as evidenced by road density, and the occurrence of native salmonids. Based on the analyses of Lee et al. (1997), road densities as low as 1 mile of road per square mile of watershed appear to have an adverse affect on some aquatic ecosystems. USFS watershed/ecosystem analysis reports also discuss the impacts of roads and other watershed modifications on watershed and stream function (USFS 1994, 1995a,b, 1998).

Fire suppression is also a component of the baseline affecting native fishes. In forested areas, departures from natural disturbance and successional processes due to human-related activities could result in substantive changes to vegetation structure and seral stage composition. These

broad-scale changes in vegetative conditions likely will increase the probability that catastrophic wildfires and large-scale insect and disease events will occur.

In summary, forestry activities that adversely affect native fish populations and their habitats are primarily timber extraction and road construction, especially where these activities affect riparian areas. These activities, when conducted without adequate protective measures, alter stream habitat by increasing sedimentation, reducing habitat complexity, increasing water temperature, and promoting channel instability. Although certain forestry practices have been prohibited or altered in recent years to improve protection of aquatic habitats, the consequences of past activities continue to adversely affect native fishes and their habitat.

Effects of Ongoing Agriculture Practices on Water Quality and Watershed Function

Agriculture consumes > 90% of water used in the Upper Klamath Basin. Agriculture, directly or indirectly, has been the most significant factor affecting aquatic species in the basin. Tillage, irrigation, and water diversions, and pesticide use when not done according to accepted BMPs, can entrain fish and block passage, dewater aquatic habitats, and release sediment, nutrients, and organics, and pesticides into streams. Also agriculture can result in a loss of riparian vegetation and alter stream morphology and hydrologic regimes, and increase water temperature. There is a substantial literature discussing impacts of agriculture on aquatic ecosystems in the Upper Klamath Basin (e.g., Miller and Tash 1967; Atkins 1970; Gearheart et al. 1995; Klamath County 1995; ODEQ 1994; Snyder and Morace 1997; Kann and Walker 1999), rather than review all these papers they are included here by reference and a brief summary is presented below.

Agriculture, including livestock grazing, is the major anthropogenic factor affecting UKL water quality (above-listed references and citations therein). Likewise the contribution of sediment into UKL and its tributaries owing to agriculture is likely to be very high as well. The combined effect of wetland conversion and agricultural use of former wetlands has had a major adverse effect on water quality in the lake (Snyder and Morace 1997) and has reduced habitat quantity and quality, reduced lake volume, and reduced buffering capacity of wetlands. Loss of riparian vegetation on tributary streams, as a result of farming practices and grazing, has likely led to increased stream temperatures, reduced base flow, and modification of stream channels. Flow diversions reduce base flows decreasing fish habitat and resulting in increased stream temperatures. Unscreened diversions also entrain fish, including suckers. Every major tributary flowing into UKL has been modified directly or indirectly by agriculture and grazing.

Kann and Walker (1999) documented external nutrient loading to UKL for 1992 and 1994 at approximately 60% of the 1990-1998 average. External loading would likely be even lower in the future due to the recent acquisitions of approximately 15,000 acres of agricultural lands surrounding UKL that were former wetlands (Agency Lake Ranch, Wood River Ranch, Tulana Farms, and Goose Bay Farms). These lands were drained during late winter and spring to allow agricultural uses during previous critical years (1992 and 1994). This drainage made up a substantial portion of the external nutrient load in those years (Snyder and Morace 1997). In 1992 and 1994 agricultural pumping contributed approximately 16% and 17% respectively of the total external TP load to UKL for the entire year (Kann and Walker 1999).

Irrigation diversions affect listed suckers by altering stream flow and through entrainment and are discussed in more detail above. Listed suckers may enter unscreened irrigation diversions and become stranded in ditches and agricultural fields. Basin streams are also channelized in some agricultural areas, especially in the Lost River drainage, reducing stream length and area of aquatic habitat, altering stream channel morphology, and diminishing aquatic habitat complexity. Oregon Department of Agriculture (ODA), through Oregon State Senate Bill 1010, is working with the agricultural community to help them meet TMDL requirements set by ODEQ. All of the sub-basins in the upper Klamath Basin of Oregon are developing TMDLs which will need to be approved by U.S. Environmental Protection Agency (USEPA). The Service is fully supportive of these efforts since they have a potential to significantly improve water quality and will therefore reduce threats and aid in the recovery of listed suckers.

Effects of Ongoing Livestock Grazing Practices on Water Quality and Watershed Function
Livestock grazing which does not following accepted BMPs, can degrade aquatic habitat by removing riparian vegetation, destabilizing streambanks, widening stream channels, promoting incised channels and lowering water tables, reducing pool frequency, increasing soil compaction and erosion, and directly altering water quality through nutrient and sediment input (Platts 1981; Kauffman and Krueger 1984; Henjum et al. 1994; Overton et al. 1993). Grazing has also led to replacement of perennial bunch grasses with annual grasses that are less effective in soil stabilization. These effects increase summer water temperatures, reduce cover, promote formation of anchor ice in winter, and increase sediment into spawning and rearing habitats.

Livestock grazing impacts on listed sucker habitat can be minimal if grazing is managed appropriately for conditions at a specific site. Practices generally compatible with the preservation and restoration of native fish habitat may include fences to manage the timing and intensity of riparian grazing, rotation schemes to avoid overuse of areas, using riders to quickly move stock through sensitive or key riparian areas, and stock tanks so that livestock concentrate outside of riparian areas. One of the major problems associated with grazing in the upper Klamath Basin is winter grazing on water soaked soils. This problem is confounded when cattle are confined or loaf or feed in one area for sufficiently long that turf is destroyed and bare soil is exposed to surface flow.

Impacts of livestock grazing on stream habitat and fish populations can be separated into immediate and longer-term or chronic effects. Immediate effects are those which contribute to the short term loss of specific habitat features (e.g., undercut banks, spawning sites, etc.) or localized reductions in habitat quality (e.g., sedimentation, loss of riparian vegetation, trampled and compacted riparian soils, etc.). Longer-term effects are those which, over a period of time, result in widespread changes in habitat quality that can occur far downstream. Geomorphic changes in streams as a result of poor grazing management can propagate up and downstream, affecting areas remote from the source of impact. Increased nutrification and higher temperatures are other habitat parameters that can occur at a considerable distance from the impact source.

Short-term effects to habitat include compacting stream substrates, collapse of undercut banks, destabilized stream banks and localized reduction or removal of herbaceous and woody vegetation along stream banks and within riparian areas (Platts 1991). Increased levels of sediment can

result through the resuspension of material within existing stream channels as well as increased contributions of sediment from adjacent stream banks and riparian areas. Impacts to stream and riparian areas resulting from grazing are dependent on the intensity, duration, and timing of grazing activities (Platts 1989) as well as the capacity of a given watershed to assimilate imposed activities, and the pre-activity condition of the watershed (Odum 1981). Nutrients, including nitrogen, phosphorous, and ammonia from cattle urine and excrement are an issue that has been little studied but could be significant where cattle are concentrated near streams and where densities are high in a given watershed (Nader et al. 1998).

Significant amounts of nitrogen enter UKL from groundwater and agricultural runoff. Of the agricultural input, oxidation of drained wetlands makes large amounts of nitrogen available (Snyder and Morace 1997). Cattle can be another source since they are numerous (>75,000 head) in the Upper Klamath basin (Klamath Tribes 1994). Data from the U.S. Department of Commerce on beef production since 1920 show that numbers increased to 1960, peaking at about 140,000 head, and decreasing to about 120,000 head today.

Beef cattle produce 30 to 50 lbs of urine and 30 to 70 lbs of feces per animal per day (Nader et al. 1998). For every ton of live animal mass about 1 lb of nitrogen and 0.2 lb of TP are excreted per day. Of the nitrogen contained in feces and urine, most is lost to the atmosphere, taken up by plants, or adsorbed to soil particles; only a small fraction enters surface or ground water under typical conditions (Nader et al. 1998). The amount of nutrients originating from cattle and reaching nearby water bodies is dependent on many variables, e.g., number of cattle, time spent near water, amount of runoff, presence of drainage ditches, and extent of nutrient uptake by grasses and forbes (Nader et al. 1998). Although a direct connection between cattle excrement, and nutrification of UKL has not been found (Hathaway and Todd 1993), it seems likely that cattle excrement is an important contributing factor, given the large number of cattle in the basin.

Long-term or chronic effects of grazing result when upland and riparian areas are exposed to activity and disturbance levels that exceed assimilative abilities of a given watershed. Increases in stream temperature and reduced allochthonous inputs following removal of riparian vegetation, increased sedimentation from in-stream, riparian and upland sources, and decreased in-stream, riparian and upland water storage capacity, work in concert to reduce the health and vigor of stream biotic communities (Armour et al. 1991; Platts 1991; Service 1992a; Chaney et al. 1990). Increased sediment loads reduce primary production in streams. Persistent degraded conditions adversely influence resident fish populations (Meehan 1991).

Intensive livestock grazing historically occurred throughout most of the Klamath River basin, and continues to be widespread (Light et al. 1996). Livestock grazing is a major land use within the Sprague River drainage, mostly in the lowland meadows and to a lesser extent in some forested areas. Confined animal feeding operations (CAFO), such as dairies, where relatively large numbers of cattle are confined in a small area can lead to severe water quality effects when runoff goes directly into a waterway. Increased BOD, *E. coli*, and nutrients are the primary factors involved. Such operations do occur in the Lost River watershed and have been identified as contributing to water quality problems. Several dairies in the area have been recently fined by EPA for water quality violations.

The Service is convinced that adoption of grazing BMPs such as riparian fencing, off-site watering, pasture rotation and resting, as well as attention to areas where cattle use is concentrated in winter, can do much to improve watershed and stream function, and water quality in the Basin.

Effects of Ongoing Irrigation Diversion Dam Practices on Suckers

Dams have played a major part in the decline of LRS and SNS. Dams block migration corridors, isolate population segments, may result in stream channel changes, and alter water quality and provide habitat for exotic fishes that prey on suckers or compete for food and habitat with them. Most of the dams affecting the listed suckers are part of the Klamath Project or are owned by PacifiCorp, and are part of the proposed action, and therefore are discussed under the effects of the proposed action section. Chiloquin Dam is the only major dam affecting suckers that is not part of the proposed action.

Suckers are known to have migrated some distance up the Sprague River to spawn (Andreasen 1975). Chiloquin Dam on the Sprague River is thought to restrict upstream spawning migrations of LRS and SNS. The Chiloquin dam was constructed in 1928 near Chiloquin. Andreason (1975) reported that passage was poor for all species in the late 1940s. A new fish ladder was built in 1965 but in the 1970s it was not passable for fish at all river stages. Consequently most LRS and SNS spawning is concentrated into a short reach on the lower Sprague River, making it easier for predators to locate the eggs and for spawning activity to expose eggs from previous spawners. More information about the dam is found in the section on baseline conditions. Additional discussion of the effects of irrigation diversion dams will be presented in the 4.0, "Effects of the Action."

Effects of Ongoing Urban Area Activities on Suckers

Human population densities in most of the UKL watershed are relatively low. Small towns like Chiloquin, Bly, and Merrill are unable to afford state-of-the-art wastewater treatment facilities, and thus they may contribute to water quality problems. Leaking septic systems located near water bodies has been identified as a problem (Klamath County 1995). Klamath County has prepared an assessment of water resources that provides many recommendations for water quality improvements. The Service is unaware of the current status of these recommendations. The county does have minimum set-back regulations for placement of septic systems and for development. These restrictions should help reduce adverse impacts to aquatic ecosystems.

Residential development in the Klamath Falls area and Merrill has likely had some negative effects on LRS and SNS through reductions in water quality. However, since the largest concentrations of listed suckers is upstream from urban areas, impacts are limited to Lake Ewauna and adjacent upper reaches of the Klamath River, and the Lost River below Merrill. Improvements to the city of Klamath Falls' wastewater treatment facility are expected to help improve water quality in Lake Ewauna. However the lake is also adversely affected by nearly a half-century of log storage. Bark deposited on the bottom has a significant biological oxygen demand as it decomposes. Logs are still being stored in rafts downstream from Lake Ewauna

and are believed to be contributing to poor water quality in that area (Elaine Snyder-Conn, Service, pers. comm.).

Ongoing Effects of Exotic Fishes on Suckers

In the final rule to list the suckers, the Service identified exotic fishes as a threat through predation and competition (Service 1988). Logan and Markle (1993) list 20 exotic fish reported from UKL and adjacent waters. Not all of these are now present since some (e.g., lake whitefish; *Coregonus clupeaformis*) were introduced but did not establish a viable population. Some exotic fishes have, however, become established and some are sufficiently numerous and, because of their feeding habits, could be potential threats to suckers (e.g. fathead minnow; *Pimephales promelas* and yellow perch; *Perca flavescens*). These two fishes are well established in UKL and elsewhere in the upper Basin. Fathead minnows are now one of the most abundant fish in UKL (Markle and Simon 1994).

Exotic fathead minnows (*Pimephales promelas)* were first reported from UKL in 1979. By the mid-1980s the population had exploded (Bienz and Ziller 1987) and they became the most abundant fish in UKL. Concern about the potential impacts of the fathead minnow on sucker larvae prompted The Klamath Tribes to assess their predatory capabilities (Dunsmoor 1993; Klamath Tribes 1995). Dunsmoor examined predation of larval suckers by fathead minnows in the lab (Dunsmoor 1993; Klamath Tribes 1995). He found that larvae were most susceptible to predation when water depth was shallow, there was an absence of cover, and larvae were young. Increased water depth, increased cover, and increased age all reduced predation rates. Adequate vegetative cover was an important variable in these experiments and suggests that emergent vegetation may play a critical role in reducing larval predation.

The Tribes submits that as water depth increases to about 0.6 m, the surface orientation of the sucker larvae and the bottom orientation of the fathead minnows results in enough separation to almost eliminate predation, even when the fathead minnows are hungry. As sucker larvae grew they became less vulnerable to predation by fathead minnows, and the pattern of decreasing vulnerability differs by species, depth, and structure. When considering the potential outcome of predatory interactions between larval suckers and other predators like largemouth bass or pumpkinseed, there is no assurance that a similar depth effect will be operative. However, decreased predatory efficiency in structurally complex habitats has been documented in the literature for these and closely related species (Savino and Stein 1982; and Heck and Crowder 1991, as cited by Klamath Tribes 1996).

A variety of exotic warm-water fishes, especially sunfishes (centrarchids) and bull heads (*Ameiuris* spp.) are also found in the Lost River. Their abundance in there is likely a result of widespread habitat modification and water management activities that have created conditions favorable to exotics, warm-water fishes.

Currently the effect of exotic fishes on listed suckers is not well understood. They are most likely a concern in areas where the habitat is highly altered and suckers are not doing well for a number of reasons. For example, in UKL, exotic fishes may play a synergistic role with other factors, e.g.,

effects of entrainment and adverse water quality in larval mortality, especially when lake levels are too low for larvae to find cover in emergent vegetation. However, it needs to be emphasized that many native fishes such as sculpins and chubs, are likely also important as predators on larval fish. The critical factor is to recover sucker populations to levels that can persist under the effects of predation and other threats.

Summary of Factors Affecting Lost River and Shortnose Suckers in the Environmental Baseline

LRS and SNS populations have been and continue to be affected by many factors, most of which have been negative, as described in detail above. Historically, the major adverse impact was direct habitat loss as aquatic habitat was reclaimed for agriculture. This resulted in the near complete or complete loss of the Tule Lake sucker populations, which were perhaps as large or larger than those in UKL. Construction of the railroad and additional land reclamation resulted in eventual loss of suckers in Lower Klamath Lake and perhaps eliminated significant areas of rearing habitat for juvenile suckers originating in the UKL sub-basin. These losses were somewhat mitigated for by construction of Gerber and Clear Lake dams, increasing sucker habitat in the upper Lost River sub-basin. Fish control measures in Lake of the Woods eliminated the distinct and isolated sucker population there.

Sucker populations in UKL sub-basin have been affected differently than those in the Lost River and Lower Klamath sub-basins. UKL populations were not affected by single large actions but rather by a series of smaller actions that continue to have adverse effects today. Unlike the Lost River and Lower Klamath sub-basins, where there were large-scale habitat losses, habitat loss in UKL sub-basin has been primarily through degradation. This is not to say that the other sub-basins are not experiencing habitat degradation, but rather habitat loss was so complete that little original habitat remains. An example is the Tule Lake sumps, which provide habitat for a few hundred suckers and is filling in with sediment to the point where relatively little of the available habitat is used and access to spawning sites is blocked.

Early in the 20th Century, UKL sucker populations suffered progressive degradation of spawning habitat owing to water development, land reclamation, and poor land management. Historical spawning areas in the UKL tributaries, including: Crooked, Crystal, Sevenmile, and Odessa creeks, and Fourmile Creek and Slough; and Barkley, Odessa and Harriman Springs, and at least four other springs in UKL have disappeared or significantly declined in the past 50 -75 years. Construction of the Chiloquin Dam likely reduced upstream spawning migrations and degradation of upstream habitat likely further reduced upstream spawning.

Currently, the major factors affecting suckers in UKL are water quality and habitat loss and degradation. Water quality degradation in the UKL watershed, as discussed above, was likely progressive. Although water quality in UKL was seasonally poor near the end of the 19th Century, as evidenced by early reports, *AFA* was likely not a significant factor until about the middle part of the 20th Century, as indicated by micropaleontology. It is likely that *AFA* became more significant as nutrients from anthropogenic sources supplemented already abundant nutrients from natural sources. As a result, UKL went from a eutrophic state of high productivity to hypereutrophic,

where primary production reaches a maximum where it is only limited by the availability of light.

As a result of a higher trophic state, water quality in UKL experiences severe declines on an annual basis. Dissolved oxygen, pH, and un-ionized ammonia all reach levels known to be stressful to suckers, and at times are lethal and have been tied to recurring fish kills. UKL has undergone three significant fish kills in the past decade, owing to *AFA* bloom/decay cycles. Also fish diseases, such as Columnaris disease, may be increasing in frequency as fish become stressed by poor water quality conditions. High rates of parasitism and abnormalities have been noted as well, and may be an indirect result of water quality degradation and stress.

Applying the principles of conservation biology (e.g., Soule 1986; Fiedler and Jain 1992), and the findings set forth in the *Lost River and Shortnose Sucker Recovery Plan* (Service 1993a), the following represents the conservation needs of the suckers:

1. Populations (or metapopulations) must occur throughout their historic range.

   This would include populations in the Lost River sub-basin (Clear Lake, Gerber Reservoir, Tule Lake, and their tributaries, and in the Lost River); Upper Klamath Lake and tributaries; and Lake Ewauna and upper Klamath River. Currently LRS are largely confined to only two areas, UKL and Clear Lake. The historic population in Tule Lake has largely been extirpated, as have some populations that spawn in springs and tributaries in UKL (e.g., Harriman and Barkley springs). Suckers in Lake of the Woods are also extirpated. Adult suckers also use only a fraction of the available habitat in UKL and Tule Lake sump possibly because habitat quality has markedly declined owing to reservoir management, nutrification, and sedimentation.

2. These populations must be of an adequate size and of a diverse age structure, to withstand stochastic events and remain viable.

   Populations needs to be sufficiently large to withstand stress and mortality associated with droughts, disease, predation, adverse water quality, high flows and cold temperatures during spawning, and other such random events that affect survival. Populations need to be sufficiently large that they do not lose genetic diversity when significant percentages of the individuals die or become non-reproductive. Diverse age structures are needed to ensure survival during events that might be age- or size-specific, such as have been suspected during UKL die-offs. Having sufficient numbers of older and larger fish is crucial because reproductive potential is size dependent.

3. These populations must be interconnected for demographic and genetic support.

   Populations must have the ability to move about and to mate with individuals from other populations to ensure beneficial genes are shared among metapopulations and to ensure loss of genetic diversity does not occur in smaller and isolated populations. This is especially important when populations are experiencing environmental stress such as are populations in UKL. Currently all major habitats are isolated from one another by dams that lack adequate

passage facilities.

4. Adequate spawning, rearing, feeding, and overwintering habitat must be present throughout the range of the species' to support viable populations.

   Populations need to occupy a broad diversity of habitats including spawning, rearing, feeding, and water quality refuge areas. These habitats must be available during the period of time they are needed, for example larvae must have adequate emergent marsh, rearing habitat where they can feed and avoid predators. Water quality refuge areas are also crucial for adult sucker in UKL so they can void adverse water quality. Adequate passage between habitats is needed so that suckers can use all habitats that are necessary for completion of their life history, such as passage between Lake Ewauna and UKL, and between UKL and spawning habitats in the upper Sprague River.

These needs will be met if there is: (1) adequate water volumes and depths are maintained in lakes, reservoirs, and rivers and streams to provide for habitat for spawning, rearing, and feeding, and cover from predators; (2) adequate water depths in lakes and reservoirs are maintained to buffer water quality during summer (e.g., pH values of <9; DO concentrations of >4 mg/l; un-ionized ammonia <0.1 mg/l, temperature < 27 C) and during winter ice-cover conditions when DO levels decline owing to sediment oxygen demand and reaeration is halted; (3) adequate water depths in lakes and reservoirs are maintained so that suckers can use water quality refuge areas (e.g., lake/reservoir depth > 4 feet for adult refuge during adverse water quality conditions); (4) adequate spring and tributary inflows to provide physical access for spawning as well as water quality protection; (5) adequate littoral areas with appropriate vegetative and substrate patterns and depth for larval and juvenile feeding and protection from predators; (6) adequate access to appropriate spawning habitats in tributaries and lakeshore areas facilitated by providing sufficient lake/reservoir depths; (7) use of best management practices by agricultural and forestry to preserve adequate water quality and habitat; (8) adequate fish passage at dams and diversions so suckers can reach critical habitats to complete life history; and (9) protection from entrainment at the numerous water diversion points throughout their range.

3.0 EFFECTS OF THE ACTION

This section analyzes the beneficial and adverse, direct and indirect effects of the proposed action, as well as any interrelated or interdependent actions affecting listed species/critical habitat. If incidental take will result, that information will be included in the incidental take section presented later in this opinion. The species addressed in this section include the LRS and SNS. The discussion is combined for the sucker species because past and continuing changes in their habitat have had a similar impact on both species.

3.1 Effects of the Action to Lost River and Shortnose Suckers

The proposed action affects LRS and SNS throughout their range, with the exception of a few stream-resident SNS in the Gerber Reservoir watershed that are likely to be unaffected by the continued operation of the Klamath Project. Since these fish are so few in number relative to those

in Project reservoirs, it can be said that the proposed action will affect the vast majority of populations throughout the species range.

Clear Lake Dam and Reservoir

The Clear Lake Dam blocks all upstream sucker movement from the Lost River into Clear Lake. Following the irrigation season, flow to the Lost River is cut off, leaving only a small amount of leakage. Fish, including endangered suckers, seek refuge in shallow pools that remain. During salvage operations near the dam in September1999 and 2000, a few LRS and SNS were collected. Large numbers of aquatic insects, snails, and unionid mussels were found freshly dead. DO in the pools was low owing to relatively high concentrations of aquatic organisms that moved into the pools and from those dying around the pool perimeters. The survival of suckers and other fish in these pool through the winter is questionable owing to oxygen depletion and increased predation. The dewatered reach of the upper Lost River below Clear Lake Dam may be as much as 8 miles long.

Implementation of the proposed water releases under Clear Lake drought operations coupled with expected lake level declines from seepage and evaporation will result in several direct adverse effects to LRS and SNS. During drought years, irrigation releases, evaporation and seepage will result in a loss of reservoir surface area and hence, a loss of LRS and SNS habitat. Surface elevations lower than 4524 ft in the months of February and March could reduce access to Willow Creek for spawning. In 1992, low lake levels in Clear Lake prevented suckers from migrating upstream in Willow Creek to spawn. A decrease in water surface elevation will also increase the susceptibility of fishes to predation by pelicans, bald eagles, and other fish-eating birds. The resulting loss of water volume could, in turn, result in increased water temperatures throughout the lake and decreased DO concentrations.

The projected water surface elevation of Clear Lake at the end of the irrigation season in drought years may potentially result in winter mortality of LRS and SNS. Clear Lake freezes in the winter and the concentration of fishes in a small volume of water under a frozen surface may result in the depletion of DO and subsequent fish kills.

With an extended drought, Clear Lake has the potential to reach elevations incapable of sustaining sucker populations due to the factors identified in the paragraphs above. This potential is partially due to natural causes, but has been greatly exacerbated by irrigation withdrawals during the last several drought years.

A primary concern for fish populations in a high elevation, shallow lake such as Clear Lake is the threat of low DO under the ice cover. In October 1992, the water surface elevation was 4519.2 ft before the onset of a hard winter, and no fish kills were observed. Accordingly, the Service is assuming that 4519.0 ft is the minimum surface elevation (the "hard-floor") at which the sucker populations can survive through the winter. However, such low water levels, even if they provide for the survival of the majority of fish, create poor water quality conditions, particularly during cold winters when the ice cover is extensive, such as 1993. As a result, the Clear Lake populations of both sucker species were in poor condition in the spring of 1993 (Service 1994b),

and could be in the future even if the 4519.0 minimum elevation is maintained.

With average inflow, evaporation, seepage, and irrigation releases, Clear Lake will stabilize at a water surface elevation of approximately 4529 ft. With average inflow, evaporation, seepage, and no irrigation releases, the reservoir will stabilize at a water surface elevation of approximately 4538 ft (M. Buettner, USBR, pers. comm.). However, at higher elevations the evaporation and seepage losses exceed the average inflow (because of increased surface area), and water levels decrease unless inflows are above average. During drought conditions the inflow must be at least 72 % of average to maintain the 4529 ft water-surface elevation without any irrigation releases and average evaporation and seepage losses. During a sustained drought, such as the previous six years (1987-1992), continued releases of 35,770 acre-ft (the average release) over-draft the lake until the physical limitations of the reservoir reduce the amount of water that can be released. On a sustained basis, this type of water management can only increase the likelihood of the lake level dropping below the hard-floor, and even desiccating (such as during the 1930s). For example, Clear Lake went from its highest elevation of 4542.3 ft in April of 1984 to one of its lowest elevations of 4519.2 ft in October of 1992, in less than a nine year period. During drought conditions the lake level can continue to decline from evaporation and seepage even if no water is released. If the lake level at the beginning of a drought is low, lake levels below the hard-floor and even to the point of near or total desiccation are possible with consecutive drought years. If the 1993 inflow was similar to that of 1992, Reclamation predicted that Clear Lake would be dry, regardless of whether or not water was released for irrigation. Such low lake levels not only affect fish and wildlife in the Clear Lake National Wildlife Refuge, but also impact water availability for irrigation.

Reclamation has developed a reservoir operations model for Clear Lake from which future storage can be predicted based on beginning storage, inflow, and outflow (Service 1994b). The model indicates virtually no chance of total desiccation without water releases, since the lake level at the beginning of a drought would be high enough to prevent this. Therefore, unless a drought occurs that is considerably more severe than any recorded to date, the volume and timing of water releases is critical in avoiding low water levels and the desiccation of Clear Lake.

The reservoir operations model was used to predict how the lake level would fluctuate in response to various inflows and irrigation releases. The model demonstrates that an October 1 surface elevation of 4521.0. ft would result in a surface elevation of at least 4,519.1 ft the following October approximately 95 percent of the time, assuming no irrigation releases. If the lake level was at or near the operating floor of 4521 ft on October 1 when a drought began, no irrigation releases would be made the following summer and the lake could reach the hard floor during the second winter of the drought. Accordingly, the implementation of a water conservation plan is necessary to avoid entering a drought at or near the operating floor.

The current irrigation system in the Langell Valley does not operate effectively, due to low flows, when Clear Lake surface elevations are below 4522 ft (M. Buettner, USBR, pers. comm.). Operations of the Clear Lake National Wildlife Refuge and the Project should be managed on a long-term basis by balancing water supplies and demands. Especially in years with low inflows, annual water releases must be reduced to prevent the otherwise inevitable lowering of Clear Lake

elevations to levels that threaten both endangered species and agriculture in the upper Lost River watershed. An operating floor for Clear Lake and an effort to balance water supplies and demands (i.e., water conservation) will improve the chances of having adequate water for fish, wildlife, and irrigation during drought periods. Without some water conservation strategy, an operating floor alone will not provide adequate protection, due to the potential for continued desiccation despite zero water releases. The reservoir should be managed so that the water level remains well above the operating floor in order to conserve water for future operations and reduce the chances of going into an extended drought with low lake levels. The action as proposed does not effectively provide for water conservation to meet the needs of fish, wildlife, and irrigation relative to Clear Lake operations.

Gerber Dam and Reservoir

Gerber Reservoir was built by the BOR in 1925 by damming Miller Creek to provide flood protection and irrigation deliveries to about 17,000 acres in Langell Valley. It has a surface area of 3,800 acres at maximum capacity and about 150 acres at minimum elevation. Capacity varies from about 93,000 to 50,000 ac-ft. The reservoir is relatively deep, with a mean depth of >20 ft and a maximum depth of >60 ft, allowing the reservoir to stratify and undergo oxygen depletion below the thermocline. In the drought years of 1992 and 1994, DO concentrations near the bottom were <4 mg/l. The reservoir is considered eutrophic and is highly productive, but not to the degree of UKL . In October, most flows to Miller Creek are cut off; however, a 1-2 cfs flow is maintained through the winter, but these flows often don't occur until as late as December. By January or February accretion flows may be sufficient to support suckers without additional releases from Gerber Dam; however, this needs to be investigated. Major Gerber Reservoir tributaries are: Barnes Valley, Ben Hall, and Wildhorse creeks.

Under previous management, the reservoir was often drawn down too low, significantly reducing available habitat and putting the suckers there at risk from water quality and other problems. In October 1992, following a 6 year drought, Gerber Reservoir reached a minimum elevation of 4796.4 ft, which is <1% of its maximum capacity. Aeration was used to maintain water quality during the preceding summer as reservoir levels dropped. Reclamation biologists found that SNS in the reservoir at that time showed signs of stress including low body weight, poor gonadal development, and reduced juvenile growth rates (Buettner, USBR, pers. comm.).

Reclamation conducted water quality monitoring at Gerber Reservoir from October 1991 to December 1994 (USBR, unpub. data). Temperature, DO, pH, and conductivity were monitored using Hydrolab Inc. instrumentation. Continuous data was collected near the dam at 1meter below the surface. Instantaneous profile data was collected at up to 8 sites around the reservoir. In 1992, an extremely low lake level year, low DO conditions were documented during the summer months. Most values ranged from 4-6 mg/l throughout the water column. In June 1992, DO reached a low of 1.1 mg/l at the bottom or the reservoir near the dam, and readings < 4 mg/l were recorded from May through mid September. In the fall, DO concentrations increased continuously as water temperatures decreased; pH values ranged from about 7.2-8.2. These relatively low pH values were probably related to high turbidity and lack of phytoplankton growth. Turbidity readings of 160-300 NTUs were recorded with Secchi disk transparencies of less than 0.5 m.

Conductivity increased throughout the year, from about 140 uS/cm in March to 210-230 uS/cm in the fall months. This increase was associated with decreasing water levels mostly due to lake evaporation.

In 1993, a wet year with relatively high lake levels, water quality conditions were much better than 1992 (USBR unpub. data). Conductivity readings dropped from about 200 uS/cm in January to 50 by March. Conductivity reading throughout the rest of the year ranged from 50-70 uS/cm. The pH values increased from 7.2-7.6 in January to 9.0-9.5 during July and August. High values were associated with phytoplankton blooms during the summer near the surface (at least the top 5 m). Lower pH values (6.8-8.0) were monitored near the bottom of the reservoir at the dam. With the large inflow of water during the late winter and spring, water transparencies improved dramatically. Turbidity readings dropped from about 200 NTUs to 10-25 NTUs, except during *AFA* blooms. DO concentrations were low during January and February associated with ice-cover conditions. Readings ranged from 3-6 mg/l in the top several meters and as low as 1.5 mg/l near the bottom. During the thaw and major runoff period in mid to late March, DO increased to 9-10 mg/l. DO concentrations during the summer were relatively high and variable in the surface waters associated with *AFA* bloom activity. Bottom DO dropped throughout the summer and early fall. In June readings were 7-8 mg/l, dropping to less than 2 mg/l in August-October. This change was associated with stratification of the lake. A DO level of approximately 2 mg/l is considered a high potential risk for suckers. Water temperatures were 3-5E C cooler at the bottom than the surface.

Water quality conditions in 1994, which was a low reservoir level year when the reservoir reached only 12% of capacity, were similar to 1993. In January and February, during ice-cover conditions, DO concentrations were relatively high in the upper 5-8 m (6-11 mg/l) and decreased to less than 1 mg/l at the bottom. *AFA* blooms occurred in July and August influencing pH and DO conditions. DOs remained above 4 mg/l in the top 3-5 m. Lower DO concentrations were recorded at deeper depths during July and August.

Sucker condition factors have varied considerably in the Gerber population. SNS captured in 1992 and spring 1993 were very thin compared to those from Clear Lake, Tule Lake and UKL, while SNS captured in 1994-1996 were substantially more robust (USBR unpub. data). Extremely low water levels, high turbidity, and low DO concentrations may have contributed to their poor condition; however, the environmental conditions associated with variability in condition factor have not been analyzed for the Gerber populations.

Suckers are entrained at the outlet of Gerber Dam. Salvage efforts in the plunge pool below the outlet yielded juvenile and age 0+ suckers in 1992 and 1993. Because of the risk of injury to personnel, salvage operations have not been continued. Downstream flows in Miller Creek are shut off at the end of the irrigation season, usually in October, as described above. The 1-2 cfs bypass is released into Miller Creek in winter to prevent the outlet valve from freezing. The Service is concerned that minimum winter flows in Miller Creek are inadequate and could likely result in mortality. Higher minimum winter flows would ensure Miller Creek remains physically connected with the Lost River, allowing out-migration of age-0 suckers and upstream spawning migrations of adult suckers in the spring. Before Miller Creek empties into the Lost River, flows

are diverted into North Canal during the irrigation season. Thus, little flow currently reaches the Lost River at any time of year.

Historic reservoir operations have likely resulted in widely ranging amounts of available habitat and water quality that has often reached stressful or lethal levels. Continuation of such operations is likely to result in incidental take of SNS. For above average inflow years when elevations are mostly above 4815 ft, the surface area of the reservoir is about 2500 acres, of which perhaps approximately 2000 acres have adequate depth and water quality to support adult suckers. During below average and dry inflow years, when minimum elevations go down to 4800 ft, the surface area shrinks to about 750 acres, reducing sucker habitat to less than a third of the that available in above average years, and thereafter decreases very rapidly, reaching only a few acres at lowest elevations. When available habitat shrinks to a few hundred acres, adult suckers are likely stressed by water quality (in summer when DO may decline from high temperatures and high BOD and in winter below an ice cover), increased competition for reduced prey availability, and increased incidence of disease, parasites, and predators. Effects of low lake levels on larvae and juvenile suckers is likely to be even greater than adults since they have lower food reserves, higher metabolism, lower mobility, and are more vulnerable to predators. Specific effects of long-term droughts on suckers in Gerber Reservoir are unknown, but because of the factors specified above, the Service considers such droughts a high risk. Therefore, until it is better known how lake level management is affecting suckers in Gerber Reservoir, the Service considers that operation of reservoir below 4810 ft elevation is likely to result in unnecessary incidental take of suckers because of possible factors discussed above and the lack of reserve in the event of long-term drought. Reclamation proposes to operate using an end of season level of 4800 ft; the Service considers 4800 ft to be a minimum level were it possible to ensure that levels would not drop lower during an extended drought. As this is not possible, the Service considers 4802 ft to be a more appropriate end of season reservoir elevation.

Dams and Diversions on Lost River

Harpold Dam, located about 3 miles below the town of Bonanza on the Lost River, is privately owned and allows irrigation withdrawals by the Horsefly Irrigation District and individual farmers. Large numbers of suckers have been observed in this area by Koch (1973), and spawning activity was reported in nearby Bonanza Springs (M. Buettner, USBR, pers. comm.). The population was reported as consisting of SNS that resemble those of Clear Lake. No LRS have been observed there in recent sampling (Buettner, USBR, pers. comm.). Spawning habitat exists both upstream and downstream of the flash-board dam. The dam has no fish passage facilities.

Harpold Dam also creates reservoir habitat upstream through the irrigation season and a pool through the winter that would not exist otherwise, allowing a population of SNS to maintain itself in the Lost River. Under drought conditions, however, this population is threatened by low water levels due to irrigation withdrawals. Wilson Reservoir may seasonally be very poor in water quality, which may result in sucker migration out of the reservoir and into the Lost River Diversion Channel (LRDC) (B. Peck, USBR, pers. comm.).

The LRDC presently can flow either east or west, depending on water demands within the Project.

In winter (non-irrigation season), almost the entire Lost River flow is diverted into the LRDC at Wilson Dam. These waters then flow downstream into the Klamath River. Winter flows, beyond the capacity of the LRDC, are spilled into the historic Lost River channel. As the irrigation season begins in spring the station 48 canal, which lies east of the proposed project site and withdraws water from the LRDC, provides delivery of irrigation water to areas south of Klamath Falls. When station 48 summer water demands exceed westward flowing LRDC flows, excess irrigation demands are met with water that is withdrawn from the Klamath River. Thus, Klamath River waters typically flow eastward through the project site when irrigation demands are high (e.g., late spring-summer) and Lost River waters flow westward through the project site when irrigation demands are minimal (e.g., after the growing season, early November through March). In addition, waters from UKL may enter into the Lost River system, and thus into the LRDC, when excess and return flows drain back into the Lost River watershed from the B, E, and F irrigation canals. Since all of these water bodies may transport endangered fishes, and none are screened, endangered suckers may be affected by adverse water quality and entrainment through pumps and other diversions anywhere in the LRDC service area.

While the LRDC does not provide the lacustrine habitat that is preferred by these lake suckers, water quality conditions in Wilson Reservoir may, seasonally, be sufficiently poor as to prompt migration out of the reservoir and into the LRDC (B. Peck, USBR, pers. comm.). A number of fish kills have been reported from the Wilson Dam area of Lost River. During late January and early February of 1997, a relatively small fish kill occurred in the southern end of Wilson Reservoir near the LRDC head gates. A minimum of 55 juvenile suckers (9-19 cm FL) were apparently killed when DO concentrations dropped to lethal levels (<1 mg/l measured by Reclamation biologists on 2/5/97) below an ice cover.

In late August and early September of 1999, a summer fish kill occurred in the LRDC below the Wilson Reservoir headgates. It is presumed that low DO conditions caused this kill when anoxic waters from the bottom of the thermally stratified Wilson reservoir were mixed upward and delivered to the LRDC. Collections of dead fish from that period included only tui chubs (*Gila bicolor*), however, abundant fish eating birds (e.g., Caspian and Forster's terns, great egrets, etc.) were present and may have consumed any juvenile suckers.

Tule Lake Sumps

Under the proposed action, the shallow, hypereutrophic condition of Tule Lake, along with persistent algal blooms, will continue to limit the amount of water in the lake with acceptable water quality for suckers and most other fish. During severe winters with thick ice cover, only small, isolated pockets of water with depths greater than three feet exist, increasing the risk of winter kills. The proposed action would also provide only inconsistent spawning flows in the Lost River.

Under the proposed action, water would be diverted from the lake and the Lost River for irrigation and also taken from Tule Lake to Lower Klamath Lake via Pumping Plant D and the Tule Lake Tunnel. These diversions may have a negative impact on the suckers (especially larval suckers) by direct mortality as they are entrained through the pumps, or mortality through desiccation,

aquatic vegetation control, predation, and poor water quality associated with the canal systems. Suckers that do survive these diversions will still be lost to the Tule Lake population and may be trapped in canals where they cannot complete their life cycle, where water quality is adverse, or where water is removed at the termination of irrigation season.

Constant high lake levels may reduce the extent of wetland and shoreline emergent areas and alter the status of species relatively intolerant to constant lake levels (e.g., hardstem bulrush). Tule Lake wetland areas have declined dramatically, including bulrush, over the last 30 years under a management regime that allowed only a one-foot annual fluctuation,. Although this problem may be the result of constant lake levels, excess nutrients, sedimentation, and other factors may be involved. Sedimentation has removed approximately 90 percent of the water depth in emergent wetlands in the Tule Lake sumps and at this rate sucker habitat will disappear in a few years if nothing is done to stop sedimentation.

Upper Klamath and Agency Lakes Management

UKL and Agency Lake will be considered as one and referred to as UKL, unless stated otherwise. Reclamation has described actual operations of the project in their BA using historical data regarding UKL, Gerber Reservoir, and Clear Lake Reservoir water elevations from October 1960 through September 1998. This period encompasses the time when existing project features/facilities have been in operation, and it is the period of hydrological and project operation records incorporated into the water accounting spreadsheet model (KPOSIM) for the Klamath Project. The Service considers this period too short to assess how long-term climatic events affect the project; therefore the Service assumes that droughts will both be longer and more severe in the future than is documented in the 38-year record.

Since 1995, Reclamation has operated the Klamath Project according to an annual operations plan. Each of these years through 1999 was an above average water year condition. The most recent annual operations plan is dated April 26, 2000 and covers the period of April 1, 2000 through March 31, 2001. This water year was a below average water year. Annual operations plans have been developed to assist Reclamation in operating the Klamath Project consistent with its obligations and responsibilities, given varying hydrological conditions. Project operation has been influenced during this period by events and actions such as: (1) varying hydrological conditions in the watershed from year to year; (2) changes in the Klamath River watershed and lands adjacent to UKL; (3) changes in agricultural cropping patterns; (4) changes in national wildlife refuge operations; (5) previous consultations under section 7(a)(2) of the Act; (6) recognition of trust responsibilities for Klamath Basin Indian tribes, both upstream and downstream of the project; and (7) its obligation and responsibilities described in the July 25, 1995, and January 9, 1997, Regional Solicitor's memoranda.

The 38 year historic data set, April through September, of net inflow data to UKL (using 1996 bathymetric data) was used in a statistical analysis to determine the hydrologic year type indicators for the KPOPSIM water model. The first step was to determine if the data fit a normal distribution. Once this determination was made the arithmetic mean (average) was calculated to equal 500,400 acre-feet (ac-ft). Next the standard deviation (based on sample) was calculated

(187,600 ac-ft). Approximately 68% of the inflow years fall within the range of 500,400 +/ 187,600 ac-ft. The average minus one standard deviation equaled approximately 312,000 ac-ft. The water years between 500,000 and 312,000 ac-ft are defined as below average inflow. Because there are significant operational spills for inflows above 500,000 ac-ft, the upper end of the area defined by mean plus one standard deviation was not used and 500,000 ac-ft was used as the above average indicator. For the boundary between critical and dry the mean minus 2 standard deviations was calculated and found to be lower than the lowest inflow on record. Since this value couldn't be used, percentile rankings were developed for the full 38 years of inflow data and the third percentile was found to be 185,000 ac-ft, which was used for the dry indicator. Anything below the dry indicator would be classified as a critical year. In summary, the net inflows for the four water year types (April through September) are: above average= >500,000 ac-ft; below average =312,000-500,000 ac-ft; dry =185,000-312,000 ac-ft; and critical = <185,000 ac-ft.

Lake level management of UKL strongly affects sucker survival and recovery. During the spring, lake elevations need to be sufficiently high to inundate lakeshore spawning sites. Necessary UKL elevation for lakeshore spawning are 4142.5 to 4143.0 ft, with the latter being preferred (Klamath Tribes, unpub. data). At Sucker Springs, the Klamath Tribes found 90% of sucker embryos at depths of 1.0 to 3.5 ft. These elevations are needed from late March to early June to ensure survival.

From June until August, higher UKL levels are necessary to inundate emergent vegetation and shoreline habitats used as cover by larval and early juvenile suckers. Adult suckers also need higher lake levels to provide adequate cover. Adult suckers primarily utilize daytime water depths between 3 -15 ft in the northern portion of the lake (Peck 2000, Reiser et al. 2001). Because the lake is so shallow, averaging only 6-10 ft., depending on lake elevation, the amount of adult habitat varies considerably. When the lake is full at 4143.3 ft, about 10,000 hectares of "potential" sucker habitat (3-15 ft) are present in the northern portion; however, at an elevation of 4138 ft, potential habitat is reduced to 5,161 hectares, a reduction of nearly 50 %, with only about 1,000 hectares in the 6-9 ft range that appears to be differentially utilized by the adult suckers (Reiser et al. 2001). As will be discussed more fully later in this document, the actual amount of habitat utilized by suckers is much less than the potential habitat, because suitable habitat for adults may shrink to a very small fraction of potential habitat when water quality is adverse (e.g., possibly as low as only a few hundred to a thousand acres near Pelican Bay).

Implementation of planned water diversions likely will directly affect LRS and SNS by reducing the extent and quality of spawning, rearing, and water-quality refuge habitat in low water years. Reduced late summer and fall water quality conditions existing in UKL can make much of the lake uninhabitable for Lost River and SNS (Coleman and McGie 1988; Coleman et al. 1988; J. Kann, Klamath Tribes, pers. comm.). Nutrients and organic matter become more concentrated and the potential for higher water temperatures and *AFA* growth increase as a result of the reduction in lake volume. When *AFA* production is high, dissolved inorganic nitrogen is usually depleted below the detection limit, suggesting that inorganic nitrogen has been depleted by *AFA* production and *AFA* has switched over to fixation of atmospheric nitrogen. *AFA* blooms usually occur when water temperatures increase, resulting in high pH values and further declines in DO. Lower lake elevations would increase the potential for more extremes in lake water temperatures as the lake

water volume and depth are reduced. The mean critical thermal maxima for SNS acclimated to 20E C (68.0E F) is 32.7E C (90.9E F) (Castleberry and Cech 1990). Metabolism in ectotherms, such as fish and invertebrates, is directly correlated with temperature; therefore, as temperature increases so does metabolism. Regardless of whether LRS or SNS experience water temperatures that approach their thermal tolerance, they, and the other biota inhabiting the lake, would be increasingly stressed as water temperatures increase and DO capacities concurrently decrease. The increased respiration would also further reduce the DO level. In addition, as lake levels drop, the net supply of DO would proportionally decline and may become too low to support the population of native and introduced fishes inhabiting the lake.

Reclamation stated in the BA that they have analyzed scientific data for UKL and determined that historic operations are not sufficiently protective to ensure the survival and eventual recovery of listed suckers in UKL. Current sucker population status data indicates that populations are relatively small and unstable, primarily dominated by fish less than 10 years old (mostly 1991 year class), and supported by development of only one strong year class since 1995 (in 1999). Reclamation also stated in the BA that opportunities for year-class establishment should be provided in all water year types, except critical years. As previously discussed, a strong year class may not develop because of many factors, including cold weather and high flows during the spawning season, low lake levels when larvae are present, and adverse water quality in summer. Since 1960, only 2 out of 40 years were considered to be critical inflow years (5% of years) (this does not include 2001, which is likely to have the lowest recorded inflow). The Service contends that, owing to the imperiled status of the suckers and the low frequency of strong year class development, management of UKL needs to optimize conditions necessary for year-class development in all year types. Because of cyclical variations in weather patterns, we consider a 38 year record to be inadequate to forecast future water conditions or to determine the probability of conditions that might prevent year-class development. Furthermore, with the threat of climate change occurring over the next century, the upper Basin may experience considerably reduced snow pack conditions, i.e., higher temperatures and rain may reduce the size and duration of the snow pack (Field et al. 1999). These conditions, should they occur, would likely put suckers at an even greater risk than they are today.

Reclamation proposes to operate Project facilities to supply water to water users and Refuges, while observing certain minimum lake-elevation criteria in Project reservoirs. Lake elevation criteria are proposed to provide for the habitat needs of the endangered LRS and SNS. UKL minimum elevations are proposed to improve habitat conditions for sucker spawning, and larval, juvenile, and adult sucker rearing, and water quality protection. Reclamation's primary goals for establishing minimum lake elevations are the protection of existing populations in UKL during all years and to provide adequate habitat conditions for age 0 survival in above average, below average, and dry years. The Service acknowledges that meeting prescribed lake elevations does not ensure year-class success or prevent sucker die-offs. Other factors including weather, *AFA* bloom dynamics, disease outbreaks, and poor water quality can all lead to year-class failure and sucker die-offs independent of lake level. However, both Reclamation and the Service recognize that high lake elevations can enhance the probability of year-class survival and reduce the frequency and magnitude of major sucker die-offs, and is the only short-term way to offset some of the threat to sucker populations in UKL.

Table 2. Reclamation's proposed minimum end of the month UKL levels (ft) by water year type (Reclamation 2001 BA).

Month	Above Average Water Years	Below Average Water Years	Dry Water Years	Critical Dry Water Years
October	4138.98	4138.36	4138.18	4136.93
November	4139.55	4138.99	4138.96	4137.80
December	4139.58	4138.80	4139.66	4138.58
January	4139.54	4139.41	4140.26	4140.01
February	4140.56	4140.15	4140.41	4140.94
March	4141.10	4141.35	4141.70	4141.80
April	4142.26	4142.15	4141.68	4141.68
May	4142.85	4142.22	4141.40	4140.70
June	4142.17	4141.30	4140.39	4139.45
July	4140.83	4140.00	4139.10	4138.77
August	4139.66	4138.85	4138.38	4137.52
September	4138.95	4138.18	4137.55	4136.84

The goal of establishing minimum elevations for critical years is to provide opportunity for lake spawning, inundation of emergent vegetation habitat during the period when larval suckers are present, and maintenance of lake levels that help ensure adequate water quality conditions for all life stages. Year class failure is likely to occur during low inflow years, for reasons discussed below. Occasional year-class failures would not be significant if they were infrequent, and strong year-classes were formed frequently enough to offset adult mortality. Potentially LRS and SNS are long-lived and, therefore, annual year-class formation would not be essential to maintain long-term population viability. However, events in the past decade suggest that adult mortality can be high and that strong year class establishment is infrequent. Accordingly, the Service considers that prudent management should optimize both year-class development and survival of all stages, but most critically adults which are essential for perpetuation of the species. Therefore, until the status of the suckers improves and water quality conditions in UKL improve, any actions that are likely to lead to significant mortality and/or year-class failure would put the species at an unacceptably high risk.

Reclamation's BA states that full pool elevations of 4143.3 ft in UKL provide the best habitat conditions for sucker spawning and larval rearing during late winter and spring. However, due to present flood operational constraints, Reclamation proposed February 15 and April 15 elevations near the upper limit of the operational flood protection envelope. Reclamation proposes to operate at levels above these minimums if hydrologic conditions allow and flood risk is acceptable. In all but dry and critical water year types UKL usually reaches the "operational full pool" elevation of 4143.0 ft in April or May. Over the full period of record, these elevations were not reached about 20% of the time because of insufficient inflows. This means that adequate carryover of water was not available in one of five years, which is highly significant to both

Project water users and to the endangered suckers.

The Service agrees with Reclamation that new scientific information suggests that, because of the current hypereutrophic conditions in UKL, maintaining lake levels as high as possible throughout the year is the only feasible short-term action that can reduce *AFA* productivity and associated stressful and/or lethal summertime water quality. The hypereutrophic conditions are a result of accelerated nutrient loading during the 20th Century. The only practical short-term means for reducing internal nutrient loading and increasing the probability for improved water quality is to maintain higher lake levels.

Effects of Proposed UKL Level Management on Adult Sucker Habitat Availability

Adult sucker habitat availability at different lake levels was assessed primarily using information from adult sucker radio telemetry studies in UKL from 1993-1998 (Peck 2000; Reiser et al. 2001). The radiotelemetry study found that radio-tagged adult suckers did not use available habitat evenly in UKL, but instead were mostly found in the northern portion of the lake, west of a line between Eagle Point and Fish Bank, south of the mouth of Thomason Creek. There is some information from trawling data that adult suckers may be dispersed more broadly throughout the lake; however, the number of positive trawl catches were low (Simon 2000a). Fall catches of LRS were in the northern two thirds of the lake, as were five of the six SNS caught, suggesting a similar distribution pattern oriented towards the northern lake.

Ninety-five percent of the radiotelemetry observations in spring and summer months were over bottom depths of from 3 to 15 ft. One percent of the observations were in water of 3 ft or shallower and only 3-4% of observations were found in water depths greater than 15 ft. These data indicate that adult suckers primarily utilize depths from 3-15 ft, at least during daylight hours (no data were obtained at might and it is possible that suckers move into shallow water then). Depths < 3 ft would not likely afford large suckers with suitable cover. It is generally accepted that preferred water depth increases with increasing fish size.

Differential use of various depth ranges by adult suckers relative to habitat availability was assessed by looking at radio-tagged sucker locations in September and October 1994, when UKL levels dropped below 4137 ft (Peck 2000; Reiser et al. 2001). This period of minimal lake elevations provides the best opportunity to observe depth utilization without the confounding influence on fish distributions caused by poor water quality, since water quality conditions improve in the fall. Also, the relative areas of deeper water are at a minimum relative to the more expansive areas of shallow waters, challenging adult suckers to find and remain in deeper waters if that is their preference. The 90 observations made in two months were associated with near bottom pH ranging from 7.3-9.0, water temperatures of 9.1-20.8E C, and DO from 3.8-11.2 mg/l. Only 1% of the fish were found in water <3 ft deep, which represented 42% of the bottom area available at a lake elevation of 4137 ft. Adult suckers generally demonstrated differential use of the depth range of 6-9 ft relative to availability of those depths in the northern section of the lake (Reiser et al. 2001). Use of 3-6 and 9-15 ft depths was similar to the relative availability of these depths, but depths shallower than 3 ft appeared to be strongly underutilized in the entire telemetry study (daytime data only). At this time the reason for the differential use of habitat in the 6-9 ft

range by adult suckers is not clear but probably related to the need for cover.

Water depth sensors built into eight radio tags deployed in the study (5 LRS and 3 SNS) indicated that adults of both species are bottom-oriented. None of the 96 measurements of fish depth showed that the fish were more than 1 ft above the bottom. Deeper waters of UKL (>15 ft) may not be hospitable to suckers due to frequent occurrence of low DO concentrations in summer months. Oxygen production by phytoplantkton and atmospheric reaeration do not adequately improve low DO in deep waters of the lake where sediment DO demand is high and where mixing is reduced. The depth/habitat patterns of smaller subadult suckers (Age 1+) are not known.

When the lake is full at 4143.3 ft, about 10,000 hectares of "potential" sucker habitat (3-15 ft) are present in the northern portion. However, at an elevation of 4138 ft, potential habitat is reduced to 5,161 hectares, a reduction of nearly 50 % (Reiser et al. 2001). The availability of habitat in the 6-9 ft range, that appears to be differentially utilized by the adult suckers, declines sharply at lake elevations below 4141 ft, from near 4000 hectares to only about 1,000 hectares at 4138 ft.

The available data demonstrate that availability of habitat within the depth range utilized by adult suckers is severely reduced at lower lake levels. Available habitat is further reduced by the synergistic effects habitat limitations caused by impaired water quality at low lake levels, as discussed below. The Service assumes that as depths decline, particularly under adverse water quality conditions, the availability of suitable habitat decreases, and suckers may be forced to choose between seeking adequate depth cover and adequate water quality.

Effects of Proposed UKL Levels to Water Quality Refuge Area Use

In summer, adult suckers frequently used areas of UKL influenced by inflows (Peck 2000; USBR 1996a; Reiser et al. 2001). Reclamation's radio-telemetry work shows suckers typically are located within a few miles of the Pelican Bay and the Fish Banks area. Other fish were found near the mouth of the Williamson River, Odessa Creek, Short Creek and Wood River. Telemetry also showed some interesting changes in sucker distributions as lake levels and water quality changed. Although areas in UKL where high quality inflows occur generally have better water quality than the rest of the lake, this is not always the case. During the 1995 sucker die-off, the Klamath Tribes monitored several sites in the transition area at the entrance to Pelican Bay. During the day cool Pelican Bay water with good water quality and high DO concentrations formed a wedge near the bottom of the lake while the upper water column conditions were warmer and oxygen levels were lower. With overnight cooling stratification broke down and the entire water column mixed, resulting in DO levels of 2.8 - 4.0 mg/l in the morning throughout the water column (Klamath Tribes, unpub. data). Levels <4 mg/l may be stressful to suckers. Data from the telemetry indicates that suckers may avoid areas of higher water quality when such areas become too shallow.

Based on the telemetry data, the critical minimum acceptable habitat depth for adult suckers is apparently at least 3 ft, and an appropriate lake elevation will provide at least this depth over the greatest area of suitable habitat, with higher elevations providing more volume to enhance water quality and provide connectivity between deeper habitats. The Service believes that it is crucial

to maintain UKL levels sufficiently high throughout the summer and fall to ensure suckers have access to the Pelican Bay refuge area. At an elevation of 4141 ft, suckers have access to the interior of Pelican Bay and along the shore north to Fish Bank where depths are over 4 ft, but as lake levels decline below 4140 ft, the area of 3+ ft depth moves farther from shore until at an elevation of 4138 ft it is about 0.5 mi east of Pelican Bay. The farther offshore this zone is the less likely it will serve as a water quality refuge. Accordingly, the Service considers that an elevation of at least 4140 ft is needed in early October to ensure suckers have access to suitable habitat containing adequate water quality in order to reduce the risk of future catastrophic die-offs.

Effects of Proposed UKL Levels on Shoreline Spawning Habitat Availability

Historically, there were many shoreline springs that were important spawning areas for LRS and SNS. However, Barkley Springs, Odessa Springs, Harriman Springs and several others along the east side of UKL are currently not being used. Sucker spawning at the few currently known areas including Sucker Springs, Silver Building Springs, Ouxy Springs, and Cinder Flat (a non-spring area) is very important. Shoreline sucker spawning can start as early as February and extend through May.

In UKL, sucker spawning has been recently documented at Sucker, Ouxy, Silver Building, and Boulder Springs along the eastern shoreline (Perkins et al. 2000a; Shively et al. 2000a). Spawning has also been documented at one non-spring shoreline area, "Cinder Flat" (Perkins et al. 2000a). During the late 1980's gravel and cobble substrates were added to Sucker Springs to enhance spawning success. Most of the other springs have not had gravels added, although substrates at all of the shoreline sites have been affected by construction and maintenance of the Southern Pacific Railroad that parallels the eastern shoreline of UKL. All of the cinder gravel substrate at Cinder Flat originated from the railroad.

At Sucker Springs the lower extent of the spawning gravel bed occurs at approximately 4138.5 ft elevation. At elevations of 4140, 4141, 4141.5, 4142.0, and 4142.5 ft, respectively, approximately 35%, 55%, 65%, 80%, and 90% of the spawning substrate at Sucker Springs is inundated to a depth of at least 1.0 ft, which is the approximate minimum depth for sucker spawning. A 2 ft minimum water depth would better ensure sufficient depth for reproduction.

In 1995, the Klamath Tribes conducted an intensive sucker spawning survey at Sucker Springs (Klamath Tribes, unpub. data). This survey documented sucker spawning in water depths of 0.6-3.8 ft. Spawning occurred primarily at two locations, an inshore shallow area near the major spring discharge and a deeper area starting about 30 ft from shore. In the inshore spawning area, the 50% cumulative frequency depth was 1.8 ft, with half the measurements in deeper water and half in shallower water. For the offshore spawning area, the 50% cumulative frequency was 2.9 ft. Subsequently, over 90% of the sucker embryos were found at depths of 1.0-3.5 ft. Nighttime visual observations made at the springs on numerous occasions over the last decade using night vision equipment (M. Buettner, USBR, pers. comm.) support the above findings. Greater water depth, i.e., higher lake elevations, may provide better cover for spawning fish, increase the size of spawning areas, and improve the opportunity, relative to both behavior and quantity of spawning substrate, for spawning and increase the likelihood of greater productivity for critical early life

periods. Effects of water depth on egg predation are unknown.

Reiser et al. (2001) describes the basis for lake level recommendations, developed for the Bureau of Indian Affairs, during sucker spawning periods at springs within UKL. The analysis included an evaluation of spawning data collected by the Klamath Tribes at Sucker Springs (in 1991) and at Ouxy Springs (in 1995), coupled with USGS, USBR and Klamath Tribes bathymetry data. The analysis resulted in the development of a spawning area inundation versus lake level relationship. The relationship was based on providing a minimum water depth of 2 ft over spawning areas; 60 percent of spawning locations at Sucker Springs were found at depths greater than 2 ft. Reiser et al. (2001) figures 5-7 and 5-8, clearly demonstrate the importance of higher lake levels during spring spawning periods (March – May 31). Ouxy Springs and Sucker Springs initially become available for spawning (at least 2 ft deep) at elevations of approximately 4141.5 ft, at 4142 ft are 15 and 25% inundated, and at 4143 ft are 45 and 70% inundated respectively (Reiser et al 2001).

In dry and critically dry years with elevations of 4141.8 and 4141.7 ft in March and April, respectively, and 4140.7 ft in May, shoreline sucker spawning areas would only be partially inundated with minimum water depths necessary for spawning; thus it is anticipated that spawning might be concentrated in narrow bands or in small patches at the deepest depths of the spawning areas (Table 3, below). The precise adverse effects that this might have are unknown, but it could result in too many eggs deposited in a small area, possibly leading to decreased embryo survival owing to dislodgement of previously spawned eggs as additional eggs are deposited; smothering of eggs; increased rates of fungal infections owing to too many eggs in a small area; and greater egg predation. Fry emergence could also reduced owing to the deposition of eggs on top of one another. Thus, the low elevations proposed by Reclamation will put these relatively small lakeshore spawning sucker populations at risk from year-class failure. The degree of this risk to the continued survival of those populations depends on the frequency of low lake levels and corresponding frequency of year class failures.

Effects of Proposed UKL Levels to Larval and Age 0 Sucker Habitat Availability

Habitat utilization studies on sucker larvae and age 0 juveniles (young-of-the-year) have indicated that high densities occur in the shallow littoral areas (Buettner and Scoppettone 1990; Klamath Tribes 1991, 1995; Markle and Simon 1993; Simon et al. 1995, 1996). Microhabitat studies by the Klamath Tribes and OSU determined that sucker larvae generally occurred at higher densities in and adjacent to emergent vegetation than areas devoid of vegetation (Klamath Tribes 1995; Cooperman and Markle 2000). Age 0+ suckers are consistently found over gravel, sand and other hard substrates in unvegetated shoreline areas (Simon et al. 2000b). The Tribes have also observed substantial numbers of age 0 juveniles in emergent vegetation in the Goose Bay area. In 2000, USGS, using trap nets, generally captured more age 0 suckers in Goose Bay emergent vegetation than adjacent unvegetated areas until early August (Rip Shively, USGS, pers. comm.). In the late summer and early fall there is a general, poorly understood, movement by age 0 suckers out of shoreline areas (Simon et al. 1996, 2000a,b).

Structural elements provided by emergent vegetation have been shown to decrease the efficiency of fish predators on larval suckers in laboratory experiments (Klamath Tribes 1995). Structural

complexity offered by vegetated habitats likely results in other benefits to larval and to a lesser extent age 0 suckers, including protection from waves during storm events, and increased diversity of zooplankton and other invertebrate prey. Buettner and Scoppettone (1990) found that about 85% of larval suckers were found in water depths between 0.3 and 1.6 ft. In laboratory experiments, fathead minnow predation was reduced in tanks with structure and water depths of about 1 ft deep compared to unvegetated tanks (Klamath Tribes 1995). A depth of 1 ft is the approximate mid-point of this depth range and represents a conservative estimate of marsh water depth needed by larval suckers.

Reiser et al. (2001) computed percent marsh edge and marsh interior inundated to a depth of 1 ft and greater for marsh areas representative of northern UKL and Agency Lake. Reclamation elevation data was used to analyze several larger marsh areas around the northern side of UKL including Upper Klamath Marsh between Pelican Bay and Agency Lake and the marsh area from Pelican Bay to Odessa Creek, as well as Wood River marsh in Agency Lake (USBR, unpub. data). Cumulative distribution of the sample points versus lake elevation were determined and graphed.

The percentage of edge sample points was considered a surrogate for the percentage of linear marsh-water interface inundated at a given elevation. At elevation 4139 ft none of the interior marsh habitat is flooded to a minimum depth of 1 ft and only about 5% of the marsh edge habitat is available to larval and juvenile suckers (Reiser et al. 2001, figure 5-3). At 4140 ft these values increase to approximately 10% and 40%, and at 4141 ft reach 50 and 70%, respectively.

Shoreline emergent habitats along the lower Williamson River and UKL shoreline of the Williamson River delta were quantified in 1998 to assess how changes in lake pool elevation and shoreline morphology influence distribution and availability of habitats provided by emergent vegetation (Dunsmoor et al. 2000). Four dominant shoreline emergent types differed in distribution and character. Hardstem bulrush occurred primarily along shorelines with west aspects in the Goose Bay area. Bur-reed dominated the Tulana and Williamson River portions of the delta, occurring along shorelines with southwest aspects in areas where islands or offshore stands of emergent vegetation appear to offer protection from wave energy. Smartweed (*Polygonum coccineum)* was absent from the river but relatively common in Goose Bay and Tulana. Mixed bulrush/bur-reed stands were interspersed throughout the delta. Shorelines lacking emergents were common in Goose Bay (50%) and the Williamson River (55%), but not in Tulana (15%). Shoreline slopes and lakebed elevations at the outermost edge of the emergent

Table 3. Comparison of the effects of historic operations on sucker habitat and water quality parameters for inflow year types by month based on minimum elevations (Reclamation 2001 BA).

Month	Habitat Parameter Affected	Above Average	Below Average	Dry	Critical
APRIL	Shoreline spawn. hab.	65-91%	63-80%	50-82%	53-83%
	UKL emerg. hab. > 1ft.	7-35%	5-35%	1-25%	1-25%
MAY	Shoreline spawn. hab.	80-100%	67-90%	45-78%	17-67%
	UKL emerg. hab. > 1 ft.	27-57%	7-35%	0-18%	0-5%
	Williamson R. emerg. > 1 ft.	18-27%	5-10%	0%	0%
	AFA dilution/light limitation	High	Moderate	Low	Low
JUNE	UKL emergent > 1 ft.	10-40%	0-15%	0%	0%
	Williamson R. emerg. > 1 ft.	5-10%	0%	0%	0%
	AFA dilution/light limitation	Moderate	Low	Low	Low
JULY	UKL emergent > 1 ft. deep	0-5%	0%	0%	0%
	AFA dilution/light limitation	Low	Low	Low	Low
AUG.	UKL emerg. veg. hab.	0%	0%	0%	0%
	Adult refuge habitat	3.7 ft.	2.9 ft..	2.4 ft.	1.5 ft.
	AFA dilution/light limitation	Low L	Low	Low	Low
SEPT.	Adult refuge habitat	3.0 ft.	2.2 ft.	1.6 ft.	0.8 ft.
	AFA dilution/light limitation	Low	Low	Low	Low
OCT.	Adult refuge habitat	3.0 ft.	2.5 ft.	2.4 ft.	0.9 ft.
MAR.	Shoreline spawning	53%	60%	69%	70%

vegetation were generally highest in the river, and lowest on Tulana shorelines. Emergent zone widths and cross-sectional areas were generally greatest on Tulana shorelines and least in the Williamson River. Shoreline aspect seemed to be an important determinant of wetland plant distribution, likely a result of shoreline interactions with wave energy. Shorelines exposed to the greatest fetch were dominated by shorelines devoid of emergents, but in Goose Bay within two

miles of the river mouth these shorelines were frequently occupied by smartweed. This two-mile stretch of shoreline is a potential target for lake management oriented towards provision of larval nursery and dispersal habitat May through mid-July, because this species may provide stepping stones of habitat to the more heavily vegetated eastern portion of Goose Bay. Marsh edge elevation of smartweed averaged 4140.5 ft in a study at Goose Bay in 1995 (Klamath Tribes 1995) compared to an average of 4140.3 ft measured in this study, indicating that little change had occurred. Marsh edge for smartweed was approximately 1 ft lower in the Tulana area, 4139.2 ft. Other emergent vegetation types also extended out into deeper water in Tulana. Bulrush, bur-reed, and mixed bulrush/bur-reed had mean outermost edge elevations of 4139.3 ft, 4139.2 ft, and 4139.4 ft, respectively.

Emergent zone habitat availability (1.0 ft and greater) in the lower Williamson River ranges from 25-35% at 4143 ft, 2-5% at 4142 ft, and 0% at 4141 ft. At Goose Bay, 35-55% of the emergent zone is inundated to one foot or greater at 4143 ft, and 5-20% at elevation 4142 ft. Only about 5% of the bulrush habitat is available at elevation 4141 ft. In the Tulana area, 35-60% of the emergent zone is available at 4143 ft, 15-30% at 4142 ft, and 5-7% at 4141 ft.

Total emergent vegetation availability, i.e, that which is inundated with water of any depth, is 85% at 4143 ft, 2-35% at 4142 ft, and 1-8% at 4141 ft in the lower Williamson River (Dunsmoor et al. 2000). At Goose Bay, 85-90% of the emergent zone is inundated at 4143 ft, 35-55% at 4142 ft, and 5-20% at 4141ft. In the Tulana area, 85-90% of the emergent zone is inundated at 4143 ft, 45-60% at 4142 ft, and 15-28% at 4141 ft.

Dunsmoor et al. (2000) and Reiser et al (2001) present figures (Figures 5-3 and 5-5 in Reiser et al. 2001) which show relationships of availability of marsh edge and interior habitats with lake elevation. The results of the Dunsmoor et al. (2000) analysis of habitat availability suggest lower habitat availability with respect to lake level than do Reclamation's results for availability of interior marsh habitat. For example, a loss of half of the marsh habitat volume at an elevation of 4142.0 ft is demonstrated in the former study versus a loss of half of the habitat availability at 4141.0 ft in Reclamation's analysis. However, this difference is essentially due to the difference in width and elevation gradient between the northern marshes and the narrow, shoreline marshes discussed above.

Surveys of emergent vegetation habitats were conducted in the lower Williamson River as early as 1991. In that year, the outermost extent of emergent vegetation was 4141.1 ft (Klamath Tribes 1991). In 1995, surveys within 0.5 miles of the mouth resulted in elevations of 4139.7 ft corresponding to the outermost extent of emergent vegetation (Klamath Tribes 1995). Matthews and Barnard (1996) collected measurements of the outermost extent of the emergent zone in the lower mile of the Williamson River, yielding a mean elevation of 4140.7 ft. These measurements compare quite well with the most recent surveys in 1998, which averaged 4140.4 ft across all emergent types (Dunsmoor et al. 2000). Lower elevations measured in 1995 may reflect the influence of low water in 1992 and 1994, which may have allowed expansion of the emergent zone.

These estimates suggest that larval habitat may be severely limited at UKL elevations below 4141

ft during the April through July period when larvae are present. Water depths less that 4141 ft during this critical period are likely to increase risk to larval suckers by increased predation and lack of adequate food, thus reducing probability of a successful year-class being developed.

Effects of Proposed UKL Elevations on Larvae: Spring (March-June)

Elevations less than full pool (i.e., <4143.3 ft) during the spring directly affect the extent and quality of rearing habitat for larval and juvenile suckers. Larval fish produced at lake shoreline and tributary stream spawning areas may be present from March through July (Simon et al. 1996; Simon et al. 2000b). Larvae are dependent on shallow shoreline areas, particularly those vegetated with emergent vegetation including *Scirpus, Polygonum*, and *Sparganium* (Cooperman and Markle 2000; Klamath Tribes 1996; Reiser et al. 2001). This vegetation provides cover from predation by fathead minnows, sculpins, and other fish, protection from currents and turbulence caused by wind and wave action, and complex structure for prey including zooplankton, macroinvertebrates, and periphyton (Klamath Tribes 1996). Also of concern is the possibility that larvae that do not reach the safety of emergent vegetation may get swept down lake by wind-driven currents and be entrained into irrigation and hydropower diversions. Emergent vegetation habitat has been greatly reduced over the last 90 years with the reclaiming of large tracts of marshes around the perimeter of UKL by dredging and diking. Approximately 40,000 acres have been reclaimed (Akins 1970; Gearheart et al. 1995). Substantial acreages of former wetlands are being restored to wetlands (i.e., Tulana Farms, Wood River Ranch, Agency Lake Ranch). However, mostly due to land subsidence, these tracts have not been connected to the lake and therefore do not provide habitat for UKL fish. Complex shoreline habitat in the lower Williamson and Wood Rivers has been greatly reduced as a result of straightening and channelizing these areas. The lower Wood River has recently been reconnected to its historic channel and rerouting of the delta reach is near completion. Emergent vegetation habitat located in the lower Williamson River and along the eastern shoreline is now confined to narrow strips perched at relatively high elevations (Dunsmoor et al. 2000). Reclamation's proposed springtime minimum elevations are needed to inundate these limited shoreline emergent vegetation habitats.

Channelization and diking of the lower Williamson and Wood rivers has shortened and widened both rivers. Habitat complexity has been lost, including meanders, variations in depth, fringing emergent vegetation, connection with adjacent wetlands, and extensive willow and cottonwood riparian areas were also eliminated. Floodplain habitat is mostly eliminated, and floodplain functions, such as nutrient removal, invertebrate production, and water storage, are minimal in the lower river sections. High springtime elevations during May and June back water up in the lower Williamson and Wood rivers resulting in slower velocities (Philip Williams Assoc. 2000, 2001). Slower velocities may delay emigration of larval suckers to UKL. Further, sucker larvae collected in the lower Williamson River frequently had empty guts and it is likely that many die of starvation before reaching the more productive shoreline habitats in UKL (Klamath Tribes 1996; Cooperman and Markle 2000). Emergent vegetation habitat in the lower Williamson River may be very important for sucker larvae survival because these areas may have more food for emigrating sucker larvae than unvegetated shoreline areas (Klamath Tribes 1996; Reiser et al. 2001).

Although the amount of emergent vegetation habitat remaining in the Williamson River is relatively

small, it may play a very critical role in larval survival. The emergent vegetation habitats may provide food resources for emigrating larvae that need to eat, since their yolk is generally depleted by the time they reach the lower river. Most sucker larvae use these habitats for a short period of time as they emigrate to the lake.

Reclamation's proposed April- June minimum UKL elevations in dry and critically dry years provides a minimal amount of the emergent vegetation habitat available in UKL (Williamson River Delta) for larval suckers, especially at the lowest elevations which provide no habitat (Table 2). Larval suckers primarily emigrate from the Williamson River to UKL during May and June. The proposed minimum April 30-June 30 elevations in dry and critical years of 4141.7 - 4140.4 and 4141.7 - 4139.5 ft, respectively, will inundate very little of the rare emergent vegetation habitats in the lower Williamson River utilized by emigrating larvae. At an elevation 4140.4 ft, only the outer edge of the emergent vegetation habitat in the lower Williamson River is inundated, and none is >1 ft deep. Lower elevations associated with below average, dry, and critically dry years are likely to have adverse effects to sucker year class success by reducing the amount and quality of available habitat to sucker larvae, and likely will decrease prey availability as well as increase their susceptibility to predators such as sculpins. Under these circumstances, there is a high risk of year-class failure for the Williamson River spawning population.

The May 31 minimum proposed elevation in critical dry years is 4140.7 ft. During above average and below average water year types, UKL usually fills during this month, providing maximum inundation of shoreline habitat for larval fish emigrating from the tributaries, particularly the Williamson and Sprague rivers. A lake elevation of 4140.7 ft is not likely to increase the probability of improved water quality conditions during May and June (Table 2). High April and May lake elevations have been related to later initiation of *AFA* blooms and lower bloom magnitude (Klamath Tribes 1995; Wood et al. 1996).

Several potential mechanisms have been identified to explain water quality benefits of high lake levels in the spring. Improved water quality at higher elevations will also benefit sucker larvae. Higher lake levels in April and May possibly delay the AFA bloom because less light reaches the bottom where resting stages of *AFA*, "akinetes" germinate to start the bloom cycle (Barbiero and Kann 1994). Also, higher lake levels/volume can reduce the rate of warming that leads to *AFA* bloom initiation (J. Kann, Aquatic Ecosystem Sciences, pers. comm.). Blooms have started as early as mid-May and as late as early July (Wood et al. 1996; Kann 1998). Once the bloom has begun, light is primarily absorbed in the upper 3 ft. Therefore the greater the depth the less the average light intensity will be over the entire water column, thus potentially decreasing the growth rate and magnitude of the bloom (Kann 1998). Also, tributaries and spring inflows can have higher concentrations of phosphorous (P) than the lake water (Kann and Walker 1999). Since these inflows are frequently at annual high volumes in spring, maintaining higher lake levels would have a diluting effect on P, possibly resulting in delayed *AFA* growth (Klamath Tribes 1995). Delaying *AFA* blooms decreases the probability that the more sensitive larval suckers will experience harmful water quality conditions caused by *AFA* blooms. High *AFA* growth rates in June can yield pH values exceeding lethal levels for larval and early juvenile LRS and SNS, as determined in laboratory bioassays (Saiki et al. 1999).

With May 30 and June 30 minimum proposed elevations of 4140.7 - 4139.5 ft in critical dry years, a year class is not anticipated to develop. Poor year class indices were documented in 1992 when May 31 elevation was 4140.7 ft. At a much higher level of 4142.6 ft, which is only reached in above average years under the proposed action, LRS and SNS year classes were possibly established (as indicated by age 0 catch rates during late summer and fall) during at least 8 of 10 years when this elevation was met or exceeded between 1988 and 1999. In 1991, another successful age 0 recruitment year, the elevation was 4142.4 ft. Although age 0 recruitment was indicated by OSU's studies, until age determinations are done for existing adult fish it is uncertain how these data relate to recruitment into the adult population.

Effects of Proposed UKL Elevations on Larvae and Juvenile Suckers: Summer (July-August)

Extensive wetland and shoreline emergent zones are important sucker habitat features in UKL. These areas provide habitat for larval and age 0 juvenile suckers (Klamath Tribes 1996; Cooperman and Markle 2000; Reiser et al. 2001), help improve water quality through nutrient removal and processing (Gearheart et al. 1995), and produce humic substances that inhibit cyanobacterial growth (Phinney et al. 1959).

Water level fluctuation is an important factor influencing emergent vegetation species composition and dynamics (Weller 1981). Constant high lake levels may lead to a substantial reduction in the extent of wetland and shoreline emergent areas and the dominance of species relatively tolerant to constant lake levels (hardstem bulrush). The effects of widely varying water levels are less well known, but may have adverse consequences when wetlands are left exposed by low lake levels.

Since completion of Link River Dam, UKL has fluctuated over a greater range than it did previously. Prior to construction of the dam and blasting of the reef, the lake fluctuated over about a 3-ft range (approximately 4140-4143 ft); afterwards the range was twice this 4137-4143 ft). Reiser et al. (2001) clearly describe why maintenance of the lake elevations in UKL at high levels does not influence extent of emergent vegetation habitats. This is because the fluctuations in lake level at UKL are annual, and hence exposed zones are rewetted every year thereby preventing any expansion of emergent vegetation into other areas. In order for fluctuations in lake level to be effective, reflooding should be minimal for 1-2 years after drawdown, thereby allowing new vegetation to become established and to grow, before being inundated. Reiser et al. (2001a), suggest that the emergent vegetation growth around UKL appears relatively stable, at least on a time scale of decades. The consistent maximum water levels of around 4143 ft every year (in most cases) likely controls both the upper and lower end of the emergent vegetation zone distribution.

The minimum proposed UKL elevations on June 30 and July 30 are 4139.5 and 4138.8 ft, respectively. At the lowest elevation no emergent vegetation and wetland habitats >1 ft deep for larvae and juveniles is inundated. Only at the higher elevation is there any available habitat, and even then it is only about 5% of that available (Table 2). The later part of this period is less crucial for larvae since most have transformed to age 0 juveniles. Although age 0 juvenile suckers occupy a wider range of habitats and are less susceptible to predation than larvae (Simon et al. 1996; Klamath Tribes 1996); low lake levels may force age 0 suckers from wetlands into open areas of the lake where food and cover my be less available and where water quality may be

adverse. Also, newly metamorphosed age 0 suckers would still be very vulnerable to sculpins. Thus, in all year types the proposed lake levels could pose a significant threat to age 0 survival.

Effects of Upper Klamath Lake Level Management on Water Quality

The proposed May 30 minimum elevation for dry and critically dry inflow years are 4141.4 and 4140.7 ft, respectively. These low lake elevations will have little probability of decreasing adverse water quality conditions during June, and in fact, are likely to contribute to such problems.

Reclamation's BA states that AFA dilution strongly influences water quality, with high dilution equating to a higher probability of good water quality. High dilution was defined as elevations greater than 4142.5, moderate dilution from 4141.5 to 4142.5, and low levels of dilution at less than 4141.5. Sediment dilution strongly influences water quality with high dilution equating to a higher probability of good water quality. Criteria used for sediment dilution were high (>4141 ft), moderate (4139-4141 ft) and low (<4139 ft).

Several mechanisms have been identified that show potential water quality benefits of high lake levels in the spring. High April and May lake elevations were related to later initiation of *AFA* blooms and lower bloom magnitude (Klamath Tribes 1995; Wood et al. 1996). By maintaining higher lake levels in April and May, less light reaches the bottom, where *AFA* akinetes germinate in order to start the bloom cycle, possibly delaying the bloom (Barbiero and Kann 1994). Also, higher lake levels/volume can reduce the rate of lake warming that leads to *AFA* bloom initiation (J Kann, Klamath Tribes, pers. comm.). Maintenance of high lake levels may also increase the probability of lower bloom magnitude due to *AFA* dilution and lower nutrient loading rates (Kann 1998; Kann and Walker 1999). With lower *AFA* growth, pH levels are usually lower and supersaturated DO levels less frequent. Fish survival, particularly the more vulnerable early life stages, is likely to be higher as a result.

AFA blooms usually occur during June-September. However, blooms have started as early as mid-May and as late as early July (Wood et al. 1996; Kann 1998). The greater the depth during the growing season the less frequent contact of *AFA* cells with light, potentially decreasing the magnitude of the bloom events (Kann 1998). In addition, water inflows from tributaries and other sources can have higher concentrations of bloom-stimulating nutrients than the lake water (Kann and Walker 1999). Maintaining higher lake levels would have a diluting effect, possibly resulting in blooms of lower magnitude (Klamath Tribes 1995). Later occurring blooms decrease the probability that the more sensitive larval suckers will experience harmful water quality conditions caused by AFA blooms; pH values during this time period have approached or exceeded lethal levels for larval and early juvenile LRS and SNS determined in laboratory bioassays (Saiki et al. 1999).

From July through October, *AFA* blooms and their decline are a dominant factor affecting UKL water quality. Maintaining high lake levels may increase the probability of smaller-sized *AFA* blooms and associated pH and DO levels that are generally lower with less daily fluctuation than would occur during large blooms. Increased lake levels lower light availability to *AFA*, which lowers growth rate and therefore limits the actual size of the *AFA* bloom. Most photosynthesis is

limited to the top meter of the water column during a bloom (Kann 1998). During a mixed situation (which frequently occurs), *AFA* spend a proportion of time at deeper depths where respiration exceeds photosynthesis, greatly retarding growth. The deeper the water column the greater the dilutional effect on *AFA* biomass. Increased lake levels dilute total phosphorus (an important plant nutrient) entering the water column from the sediments, which in turn limits the maximum possible size of the *AFA* blooms (Klamath Tribes 1995). These two direct effects of lake level are then enhanced further by the positive feedback cycle. In this cycle, *AFA* growth raises pH and thereby stimulates the release of TP from the sediments, creating the potential for *AFA* to reach even higher biomass. Increased lake level inhibits this cycle through each of the two direct pathways (Figure 1).

During late summer and early fall, *AFA* die-offs occur with increased frequency, leading to low DO and high un-ionized ammonia concentrations that result in stressful and/or lethal conditions for fish. At lower lake levels, the ratio of lake volume to sediment surface area decreases (Klamath Tribes 1995). As this ratio decreases (i.e., there is a lower volume relative to sediment area), the depletion rate of DO in the water column increases because the lower water volume holds less oxygen relative to the biochemical oxygen demand of the sediments. It has also been shown that increased resuspension of sediments, that is higher at lower lake levels, causes more depletion of oxygen and release of ammonia into the water column (Leanen and LeTourneau 1996). Additionally, during calm periods there is an increased risk of poor water quality at lower lake levels. During calm periods, hypoxic/anoxic (little/no DO) conditions occur at the lake bottom leading to greater production of ammonia which is subsequently mixed in the water column when winds occur. Low DO conditions also occur near the bottom under calm conditions due to high biochemical oxygen demand and a lack of reaeration from mixing. When mixing subsequently occurs the low DO is spread throughout the water column. Large *AFA* blooms and subsequent crashes have occurred during late summer in 1995, 1996, and 1997 (Perkins et al. 2000b).

As lake elevations decrease during August and September, the frequency of harmfully-low DO levels increases as shoreline rearing habitat decreases (Klamath Tribes 1995; Wood et al. 1996; Dunsmoor et al. 2000). Warm temperatures can persist through September, increasing the risk of low DO due to high sediment DO demand and high physiological rates of organisms including *AFA*. The proposed UKL minimum elevations for August 30 and September 30 range from 4136.8 to 4138.4 ft for dry and critical water year types. At these low elevations, conditions are nearly optimal for *AFA* bloom development. The shallow water column provides for maximum nutrient loading and provides optimal light conditions, allowing high *AFA* biomass to develop. When large *AFA* blooms decline the water column can be stripped of DO.

Water quality conditions are generally better in and adjacent to marshes (Forbes et al. 1998). The humic substances present in the marsh waters appear to inhibit *AFA* growth. With low *AFA* densities, water quality is generally better in the marsh edge areas than open water areas (except when wind and currents carry large concentrations of *AFA* into these areas). Exposing submerged wetlands and shoreline sediments to air during late summer and fall, may increase the oxidation of these soils and could result in the release of nitrogen and phosphorus into the lake when water levels inundate these areas. These nutrients are subsequently available for *AFA* growth the following season.

During the winter months *AFA* growth is minimal, most fish and other organisms are relatively inactive, and water quality conditions are generally good. However, harmfully low DO levels can occur during ice-cover conditions (Klamath Tribes, unpub. data). They may reach lethal levels if ice-cover persists for a long time and/or a snow-cover reduces light penetration. During most years, Upper Klamath and Agency lakes are covered with ice for a period of several weeks to several months. This ice-cover usually occurs between December and March. The depletion rate of DO in the water column increases as the depth/volume of the lake decreases because the lower volume holds less oxygen relative to the biological oxygen demand of the sediments. At a minimum lake elevation of 4140.0 ft, the probability that low DO conditions would occur during ice-cover conditions are likely reduced compared to lower lake elevations. These elevations would dilute un-ionized ammonia levels if they are elevated sufficiently to be toxic.

Ice-cover also eliminates wind-induced mixing that adds oxygen to water and prevents stratification. With ice-cover stratification occurs and near bottom water may become anoxic, leading to release of high levels of un-ionized ammonia from the sediments into the water. When the ice-cover breaks up the high ammonia mixes throughout the water column, with the potential to negatively affect sucker growth and survival.

The proposed minimum elevations for December 30 range from 4138.6 to 4139.6 ft for all year types. With the proposed minimum elevations the probability that low DO conditions would occur during ice-cover events are higher than at elevation 4140.0 ft. Although little is known specifically about the effects of ice cover on UKL suckers, the Service is concerned about the potential risk it poses to suckers in general. Consequently, until more information is gathered, we assume it may pose a potentially high risk to overwintering age 0 and older suckers. The BA states that winter-kill risk of the proposed action ranges from low to high. We do not disagree. Reclamation's criteria for winter-kill risk include: high (<4139), moderate (4139-4140) and low (>4140).

Effect of Water Year Types on Suckers in UKL

The following analysis examines the effects of historic surface elevations, as controlled by Reclamation, on water quality and sucker habitat by season and water year type for UKL. It is based on Reclamation's description of "Water Year Comparisons," section 7.1.5 of the BA. Italics are used to emphasize key sections of the analysis where significant adverse impacts were anticipated by Reclamation.

Above Average Inflow Year Types

Above average inflow year types represented 53% of the years in Reclamation's analysis. On average, Reclamation anticipated that during above average water years, UKL lake levels may provide adequate habitat for shoreline spawning, emergent vegetation in the lower Williamson River and UKL for larval and age 0 juvenile sucker rearing, offshore deep-water for juvenile and adult suckers, and refuge areas near freshwater inflows. Water depths were considered to be sufficiently deep to reduce the probability of large algae blooms and associated poor water quality, and depths were thought to be high enough to reduce the probability of poor water quality

associated with bottom sediments. The risk of winter-kill appeared to be low.

However, Reclamation determined that the lowest monthly elevations during above average water years may not be sufficiently high to provide adequate water quality and habitat for the suckers. Emergent vegetation habitat would be reduced during June and July, possibly resulting in lower survival of sucker larvae and age 0 juveniles. *"Algae and sediment dilution are moderate to low from June through October leading to an increased risk of poor water quality that is harmful/lethal for endangered suckers."* Also, Reclamation specified that there would be a moderate risk of winter-kill in December and January.

Below Average Inflow Year Types

Below average inflow year types represented 30% of the years in Reclamation's analysis. Reclamation considered average elevations during below average years to be adequate for shoreline spawning areas, offshore deep-water habitat for juveniles and adult suckers, and water quality refuge areas. *"However, emergent vegetation habitats in the lower Williamson and UKL are reduced during June and July potentially resulting in slower growth and lower survival of larval suckers. There is an increased risk of poor water quality because algae dilution was moderate in the summer and fall. Sediment dilution indices are also moderate suggesting an increased risk of poor water quality particularly low dissolved oxygen that may result in reduced sucker growth and survival."* Reclamation specified that there would be a low risk of winter-kill based on the average monthly values.

Reclamation considered that during below average years minimum lake levels may adversely affect water quality or sucker habitat. *"Very little emergent vegetation habitat is inundated in June and July in the lower Williamson River and UKL leading to lower growth and survival of sucker larvae."* Reclamation predicted low to moderate algae and sediment dilution from May to October increasing the risk that adverse water quality would negatively affect sucker viability. *"Water depths in water quality refuge areas in August and September are <3 ft deep. Adult suckers may have to occupy areas with potentially harmful/lethal water quality. The winterkill index values are moderate to high in December and January."*

Dry Inflow Year Types

Dry inflow year types represented 13% of the years in Reclamation's analysis. Reclamation considered that, during average lake elevations in dry inflow years, sucker shoreline spawning habitat and offshore deep-water habitat for juveniles and adults might be adequate. *"However, emergent vegetation habitat in the lower Williamson River and UKL in June and July are small. Adult water quality refuge habitat is <3 ft deep in September potentially forcing fish to occupy areas with poor water quality. Algae and sediment dilution index values are low to moderate from May to October suggesting that there were increased risks of poor water quality."* The risk of winter-kill was considered low, based on the average elevations.

Assessing minimum lake levels in dry years, Reclamation determined:*" habitat for shoreline spawning, larval and age 0 juvenile rearing, offshore deep-water areas for adults, and refuge*

areas are all potentially inadequate for UKL sucker populations . Also, algae and sediment dilution during the summer are low resulting in an increased risk of poor water quality that may be harmful/lethal for suckers."

Critically Dry Inflow Year Types

Critically dry inflow year types represented 5% of the years in Reclamation's analysis. Reclamation considered that: "*Critical dry years would result in reduced shoreline spawning habitat, reduced emergent vegetation habitat for larval and age 0 juveniles, reduced offshore deep-water habitat for adult suckers, and reduced water quality refuge areas that may adversely affect sucker survival. Algae and sediment dilution indices are low indicating that there is a higher risk of poor water quality in UKL potentially having an adverse affect on sucker survival. There is a higher risk of winterkill than at higher lake levels."*

Reclamation's analyses determined that, except during most above average years and some below average years, on-going UKL operations could have the following effects:

1) "...may lead to significant loss of shoreline spawning habitat, thus likely reducing spawning success of lake spawning stocks;"

2) "...lead to substantial loss of larval and juvenile sucker habitat during the spring and early summer, thus potentially reducing the frequency and magnitude of year class success of river and lake spawning fish;"

3) "...contribute to light and nutrient conditions that promote *Aphanizomenon flos-aquae* blooms, thus increasing the frequency and magnitude of stressful and potentially lethal water quality conditions and thus adversely affecting survival of all life history stages;"

4) "...contribute to poor water quality during algae decay cycles by reducing lake volume/bottom surface area ratios that influence dissolved oxygen and un-ionized ammonia concentrations and thus adversely affecting survival of all life history stages;"

5) "...contribute to loss of or reduction in access to water quality refuge areas adjacent to freshwater inflow areas which are important to ensure adult sucker survival; and contribute to poor water quality conditions during winter ice-cover conditions by reducing lake volume/bottom surface area ratios that influence dissolved oxygen and un-ionized ammonia concentrations and thus adversely affecting adult and juvenile survival."
6) "Additional effects include significant loss of all life stages, but especially larvae and age 0 juveniles through entrainment and passage of suckers into areas of preferred habitat or to spawning areas thus reducing survival and reproduction."

In summary, Reclamation determined:

"These potential adverse effects of implementation of the proposed action would cumulatively likely reduce the frequency and magnitude of year class success and

development and adversely affect juvenile and adult survival, and prevent recovery."

It is clear from Reclamation's summary statement that it considered year-class development and juvenile and adult survival essential for long-term population viability and recovery. It is also clear from Reclamation's analysis that significant adverse effects to suckers would likely occur during some years, and that the level of impact would be so great as to adversely affect survival and prevent recovery. The Service concurs.

Although we generally concur with Reclamations analyses for the effects of water year types on suckers, we have several key differences in what minimum lake levels are needed and when. Our review of the available data indicates that a minimal UKL elevations should be 4141.0 ft on January 1st; 4141.5 ft on February 15; 4142.0 ft on March 15th; 4142.5 ft on April 15th and June 1st; 4141.5 ft on July 15th; 4141.0 on August 15th; 4140.5 ft on September 15th; and 4140.0 ft on October 15th; regardless of inflow year type.

Minimum elevations of 4141.0 ft on January 1st; 4141.5 ft on February 15; 4142.0 ft on March 15th; and 4142.5 ft on April 15th are needed to provide adequate water depth in shore-line spawning habitat along UKL eastern shore from February -May to ensure adequate development of LRS and SNS year classes.

Minimum elevations of 4142.5 ft on April 15th and June 1st; 4141.5 ft on July 15th; and 4141.0 on August 15th are needed to provide adequate water depth in emergent-vegetation habitat in the lower Williamson River and in UKL for larval and juvenile suckers to ensure adequate year-class development. Emergent-vegetation habitat is critical for survival of larval and juvenile suckers, which are essential to provide for future generations of suckers as adults die from fish kills, predation, or from other factors.

Minimum elevations of 4142.5 ft on June 1st; 4141.5 ft on July 15th; 4141.0 on August 15th; 4140.5 ft on September 15th; and 4140.0 ft on October 15th are needed to maintain adequate water depths in UKL to reduce the magnitude and frequency of fish kills resulting from lethal water quality conditions as a result of *AFA* bloom crashes from June-October. If the frequency and magnitude of the fish kills are not reduced LRS and SNS populations will decline and reproduction will be reduced. This is likely to lead to the extirpation of UKL sucker populations.
Minimum elevations of 4141.5 ft on July 15th; 4141.0 on August 15th; 4140.5 ft on September 15th; and 4140.0 ft on October 15th are needed to maintain adequate water depths in water-quality refuge habitat in Pelican Bay-Fish Bank areas in UKL from July-October to help protect adult suckers from the lethal effects of adverse water quality conditions as a result of *AFA* bloom crashes. By ensuring adequate water depths in this refuge area, it will allow some suckers to find good water quality during periods when lethal water quality conditions exist over most of UKL. Without some adult survival, extirpation of UKL sucker populations is likely to occur.

Minimum elevations of 4140.0 ft on October 15th, 4141.0 ft on January 1st; 4141.5 ft on February 15; 4142.0 ft on March 15th; 4142.5 ft are needed to maintain adequate water depths in UKL to reduce risk of lethal water quality (un-ionized ammonia and low DO) and under ice-cover conditions from December -March to protect juvenile and adult suckers. High lake levels in

October will help ensure that adequate levels of DO will be present in the water column once UKL freezes in November or December. High lake levels during freeze-up, November- March, will help ensure that adequate DO will remain to support adult and juvenile suckers in winter when the sediment will be removing DO and an ice cover prevents atmospheric reaeration. Colder temperatures and lower pH levels experienced in winter may also make un-ionized ammonia more toxic to suckers. Without some winter survival, extirpation of these populations is likely to occur. These minimum elevations are also needed to ensure there is some year-to-year carryover of water in case of droughts. Carry-over will help maintain UKL elevations in critically-dry years when inflow might be inadequate to maintain necessary minimum lake levels in the following year.

The more-protective elevations were deemed necessary to reduce uncertainties about the frequency of environmental conditions that affect year-class development and adult survival, such as weather and climate changes. For example, the past decade (with inclusion of 2001) has been extraordinary in the extremes of weather experienced, with three record or near-record droughts. We have also had to consider that biological factors, such as, the incidence or severity of Columnaris disease, could be more extreme than it has been in the past. The combination of these environmental and biological factors led to major fish kills in the 1990s. These more conservative assumptions are necessary because we cannot accurately forecast what conditions will be like in the future, and assuming they will be identical to those experienced in the 38 year period of record is not prudent management of endangered species. Congress instructed the Service to provide the "benefit of the doubt" to the species of concern when formulating its biological opinion (H.R. Conf. Rep. No. 697, *supra*, at 12).

Effects of the Proposed Action on Sucker Passage

None of the six primary, Klamath Project dams operated by Reclamation, or those operated by PacifiCorp downstream, are fitted with passage devices adequate to pass suckers effectively. None of the projects are designed such that suckers that pass downstream over the dams, or are entrained in the irrigation system, are able to return upstream to spawning and rearing areas. The fish, therefore, lose access to essential adult habitat (e.g., Upper Klamath Lake), and have no way to escape adverse conditions downstream (e.g., dewatering). Populations upstream and downstream of the dams are physically isolated and, therefore, genetic exchange between populations is severely restricted (one way exchange). Hybridization between sucker species trapped below dams may also occur at higher frequencies, because spawning fish are restricted to small and inadequate spawning areas. Only three facilities, the Link River, Keno, and J.C. Boyle dams have some form of fish ladder. However, all of these ladders have design limitations, were intended only for salmonids, and are of limited utility for suckers. Clear Lake, Gerber, Malone, Wilson, and Anderson-Rose have no fish passage facilities.

Prior to construction of the Link River Dam, there were apparently large spawning runs of suckers migrating up the Link River in the Spring, which were described as "immense congregations" of fish weighing two to six pounds (Klamath Republican 1901). The origin of these runs is not recorded; presumably, they came up out of Lower Klamath Lake or the Lake Ewauna/Keno reach, as lentic habitat was not available below Keno prior to construction of J.C. Boyle dam. Millions

of sucker larvae and tens to hundreds of thousands of juveniles are currently entrained at the head of Link River through the A-Canal and Link River hydropower diversions (see Effects: Entrainment). Screening of the diversions would result in a greater number of young suckers moving downstream into the Keno Reach and J.C. Boyle Reservoir. This potentially vital component of the lake sucker populations currently have little ability to return to the lake when they approach maturity and are ready to enter the breeding population.

Link River Dam is equipped with an old, and apparently ineffective, fish ladder originally intended to provide upstream passage for salmonids through the Link River to UKL (Ott 1990; PacificCorps 1997). The ladder is used marginally by trout, with low numbers of suckers apparently entering the ladder only in high flow years (PacificCorps 1997). The ladder is a pool and weir type which was retrofitted to the dam in 1926. In 1952, a spillway apron and training walls were installed downstream of six stoplog bays, and the stoplogs were replaced by gates. In 1975, the stoplogs in the other bays were joined together to form wooden gates, and a lifting mechanism was installed. A vertical slot entrance pool was added in 1988. It is currently about 105 ft long, gaining 13 ft in elevation, with 11 pools. Flow through the ladder is approximately 15 cfs. The weir exits into Upper Klamath Lake at elevation 4,138.5 ft; when lake elevations are below 4,138.5 ft, the ladder is impassable.

PacifiCorp conducted a study in 1990 to identify actions that could be implemented to improve fish passage at Link River Dam (Ott Engineers 1990). Deficiencies of the fish ladder were identified by Ott as: an approach through a long channel with little attraction flow, a poor entrance requiring fish to cross a shallow cascade, small pool volume and shallow water in the lower pools, lack of self-regulating flow adjustment, and general disrepair of the weir baffles. Very low numbers of suckers have been recorded from the Link River fish ladder, which appears to be related to operational procedures, indirect routing to the ladder mouth, inadequate passage facilities, and a low-flow fish barrier located downstream of the dam (Ott Engineers 1990; PacificCorps 1997).

From 1988 to 1991, a cooperative study was conducted by PacifiCorp and ODFW to evaluate the status and effectiveness of fish passage at the Link River and other Klamath River fish ladders (Hemmingsen et al. 1992; PacificCorps 1997). Sucker data from this study are available from two sources, original data sheets apparently from J. Fortune (ODFW undated), and the PacificCorps (1997) report which summarizes the data; the two sources provide slightly different numbers, but the data sheets provide more specific information.

At Link River (Fortune data), a total of 19 suckers were caught during the study period, including 4 LRS (525-585 mm FL), 3 SNS (410-465 mm), 2 largescale (600-625 mm), 7 Klamath smallscale (395-475 mm) and 3 unidentified juveniles (187-212 mm). Suckers were present in the ladder only in 1989, a high-flow year with releases from Link River Dam reaching 3,900 cfs, and only in the Spring (April 5 to June 7). PacificCorps (1997) reported a total of 18 suckers, including 4 LRS, 3 SNS, 6 largescale, 3 Klamath smallscale and 2 unidentified juveniles. Adult suckers were also sighted incidentally by PacificCorp at the mouth of the fish ladder in 1996 (Frank Schrier, Pacific Corps, pers. com. cited in USBR 2001), and Reclamation captured two adult suckers from the ladder in June 1998 (USBR 2001).

At Keno (Fortune data), a total of 141 suckers were caught during the study period, including 8 adult LRS (480-610 mm FL), 4 SNS (221-424 mm), 103 Klamath smallscale (285-514 mm), 5 unidentified suckers (186-424), 21 unidentified juveniles (no lengths), and apparently no Klamath largescale suckers were identified. The LRS were all caught in May-June 1988-89. The SNS were caught in April, July and September of 1990-91. The smallscale suckers were caught August-October 1988 (13: 285-514 mm), April-June 1989 (71: 310-512 mm) with just two on October 12, April 1990 (6: 368-436 mm) or August-October 1990 (9: 402-480 mm), and September 1991 (2: 407-409 mm). Unidentified suckers were caught in April 1990 and September 1991 (5: 186-424 mm). Unidentified suckers recorded as juveniles with no lengths were caught in August - September 1989 (6), August 1990 (5), and late July-September 1991 (10). PacificCorps (1997) reports a total of "130 suckers", including 6 adult LRS, 3 SNS, 6 largescale, 99 Klamath smallscale and 22 unidentified juveniles (note incorrect addition).

No suckers were caught in the J.C. Boyle fish ladder during the PacificCorps study. However, a 1959 trapping study was done at the J.C. Boyle ladder by ODFW (Gerlach 1959, summarized in PacificCorps 1997). In contrast to the 1988-91 study, the earlier trapping caught a total of 2,380 suckers from May 10-December 12, 1959. Peak catches occurred between June 1and August 1, and apparently stopped when water temperature dropped below 54E F. The suckers ranged from 4-21 inches in length and were identified as Klamath smallscale and Klamath largescale suckers (within a general class of "trash fish"). The total absence of LRS and SNS suggests that these identifications of "smallscale" versus "largescale" may be generalized rather than taxon specific. It is noteworthy that the magnitude and timing of the 1959 catches is very different (summer vs. spring) from the 1988-91 passage study results.

The presence of low numbers of adult suckers in the Link River and Keno fish ladders, even given the limitations of the facilities as discussed above, demonstrates that suckers are surviving downstream and are still attempting to return to Upper Klamath Lake when they approach maturity and are ready to enter the breeding population. The inadequacies of the present passage facilities exacerbate the adverse effects of entrainment and eliminate the contributions that this potentially vital component of the sucker populations could make towards recovery.

Effects of the Proposed Action on Sucker Entrainment

Extensive entrainment of suckers occurs in many diversions throughout the Klamath Project. Entrainment of suckers and other fish at these diversions has been shown to be a substantial source of mortality for both larval and young suckers, as described below. There are no fish screens at Project diversion sites that meet State or Federal screening criteria. Reclamation has not complied with installation of a screen facility requirement on the A-Canal, as directed by an amendment to an RPA in the 1992 BO, and has at this time committed to no additional screening at any of its facilities. The fact that adequate screening has not been provided anywhere within the Klamath Project after nearly a century of operation is considered by the Service to be a major factor imperiling and retarding the recovery of the two endangered suckers.

Numerous point diversions exist on the Klamath Project, including A-Canal and most canals linked with it, Clear Lake outlet, Gerber outlet, J-Canal, Q-Canal, Pumping Plant D, and Lost

River Diversion Canal (USBR 1992a), as well as the two hydropower diversion canals located on the east and west river banks of the Link River Dam. Reclamation inventoried most non-Project pump diversions in the Lost River in 1998 (USBR 2000b). Diversions use either gravity or electrically powered pumping stations (USBR 1992a). Reclamation, through its contractors (irrigation districts), has implemented measures to reduce stranding in canals at the end of the irrigation season and has conducted, and proposes to continue, annual salvage operations in Project canals to reduce incidental take (USBR 1992b, 1993c, 1994a, 1994b, 1996c, 1997, 1998a, 1999a, 2000b). The proposed action does not pose any additional impacts related to gravity and pumped diversions than considered in previous consultations.

The two principal entrainment sites which have been monitored are the A-Canal, a large irrigation diversion canal (operated April - October) located just upstream from the Link River Dam, and the two hydropower diversion canals (operated year-round) at the Link River Dam. Results of these studies, as well as ancillary information available from other diversions, are discussed below.

Larval Sucker Entrainment

Larval sucker entrainment into the A-Canal was evaluated in 1990, 1991, and 1996-1998 (Harris and Markle 1991; Markle and Simon 1993; Gutermuth et al. 1997, 1998b). Larval entrainment results from 1998 have not been reported. Although three different entities were involved in the entrainment studies, standardization of methods and gear were employed as much as possible. The earlier studies did not address diurnal variability in drift magnitude, which later studies demonstrated was significant, with larval movement considerably higher at night (Gutermuth et al. 1998b). Larval entrainment monitoring also took place at the split of the B-Canal and C-Canal, 8.6 miles into the canal system, in 1996 and 1997 (Gutermuth et al. 1998b). Sampling methodology at the C-canal harvest site was substantially different than the drift net sampling performed in the A-Canal, and it is probable that some of the A-Canal entrained suckers did not reach the B-C sampling site.

The seasonal timing of larval drift into the A-Canal and nearby Link River Dam diversion canals was similar. Larval suckers were collected as early as April 28 on the Eastside diversion canal. The earliest A-Canal date was May 19, 1997, the first day sampled that year. The commencement of larval sucker entrainment was likely missed in 1990, 1996, and 1997 due to a late start date for sampling. In 1991, sampling began April 7 and the first larval sucker was collected on May 21. Low densities of sucker larvae may have gone undetected due to the sub-sampling protocol. Peak larval sucker entrainment occurred during June for the A-Canal and Link River Dam locations. In 1990 and 1991 substantial numbers of larval suckers were also documented in early July. Termination of larval sucker entrainment generally occurred in mid to late July. However, in 1996 larvae were captured as late as August 11.

The highest density of drifting sucker larvae occurred during the early morning (dark) hours (0000-0800) at the Eastside and Westside, followed by evening and daytime (Gutermuth et al. 1999). This same pattern was exhibited in the A-Canal in 1996. Diel patterns of drift were not obvious during 1991 and 1997 in the A-Canal. Movement patterns in the canals are apparently similar to the Williamson River where migration occurs primarily at night or during early morning hours

(Buettner and Scoppettone 1990; Klamath Tribes 1996). The greatest density of canal drift was usually associated with the surface layer (Harris and Markle 1991; Gutermuth et al. 1998b). This pattern of distribution was also documented for sucker larvae in the lower Williamson River (Buettner and Scoppettone 1990; Klamath Tribes 1996).

Larval entrainment was found to be high in all studies. The lowest estimate was in the1990 A-canal entrainment study, when approximately 400,000 larvae were entrained (Harris and Markle 1991). Entrainment was likely greatly underestimated in this study because sampling began too late in the season, after much of the entrainment was suspected to occur, and there was no nighttime sampling. In the 1991 study, under similar constraints, it was estimated that 800,000 sucker larvae were entrained into the A-Canal (Markle and Simon 1993). The more complete 1996 and 1997 entrainment estimates (full season and 24 hr sampling) for larval and early juvenile suckers (<74 mm) were 3,000,000 in 1996 and 1,700,000 in 1997 (Gutermuth et al. 1998b).

Juvenile and Adult Sucker Entrainment

Studies designed specifically to quantify juvenile and adult sucker entrainment into the A-Canal were conducted in 1997 and 1998 (Gutermuth et al. 2000a). Fish catches were extrapolated, based on percent of daily flow sampled, to develop entrainment indices that accounted for un-sampled volumes of water and periods of time and provided estimates for total entrainment into the A-Canal. The total 1997 and 1998 A-Canal entrainment index (based on both screw trap and fyke net collections) was estimated at 46,708 and 246,524 postlarval suckers, respectively. The screw trap caught mostly Age 0 suckers under 165mm FL, while the fyke net generally caught the larger Age 1+ suckers. Most of the difference between years was due to large catches of Age 0 suckers in 1998. The sucker entrainment index derived from the screw trap catches was about five times higher in 1998 (44,974 vs. 245,642). For both years, the majority of Age 0 suckers were caught in August (71% in 1997 and 69% in 1998) and September (14% in 1997 and 27% in 1998). The fyke net sampled larger individuals, generally over 250mm FL, which were caught from July through October. A peak of entrainment rates for large suckers (>15 cm FL) in August-September 1997 was associated with a drop in DO and was considered primarily the result of stressed and debilitated fish moving from severely degraded water quality conditions in UKL during a fish kill. Numerous age 0 fish in relatively good condition were also collected at that time. While these younger fish were likely stressed to a degree by poor water quality conditions in 1997, the similar 1998 patterns suggest an annual emigration from the lake (Gutermuth et al. 2000b). The driving force of this emigration is not clear.

Fish entrainment studies were also conducted at the two hydropower diversions (East and West sides) on Link River Dam in 1997, 1998, and 1999 (Gutermuth et al. 2000b). Although sampling methods were different from those employed at the A-Canal, entrainment results were similar between years, and juvenile suckers were caught primarily in August and September. While sampling only occurred throughout the year in 1998, the principal period of sucker emigration (July - September) was sampled in all three years and the total entrainment indices probably approximate the total annual entrainment. Juvenile suckers under 150 mm FL made up 91%, 99% and 99% of the total suckers in the three years, respectively. The estimated annual entrainment of suckers for the two Link River canals combined was 21,182 (1997), 82,817 (1998) and 41,405

(1999); most of these were Age 0 fish.

Additional evidence for entrainment of juvenile and adult suckers comes from the New Earth Corporation monitoring of their canal collection sites and from Reclamation's annual salvage operations in the canal system. New Earth Corp. monitored larger suckers (> 75 mm FL) that were found on their debris reduction screens and on AFA harvest screens in 1996 (Gutermuth et al. 1997). One-hundred-fifty-seven suckers were collected off the debris screens and 140 off the harvest screens. Many of these fish were probably dead before they reached the screens. During August and September substantial numbers of large juvenile and adult suckers were collected at the headworks of the A-Canal associated with a die-off in UKL. Also, low DO conditions in the A-Canal during August apparently led to a fish die-off within the canal. A trap net was also fished in the B-Canal just downstream from the Cell Tech (New Earth Corp.) *AFA* harvest site. Two-hundred-fifty-seven juvenile and adult suckers were captured between June 24 and October 20. These fish represented a relative abundance of age 0, early juvenile, and older suckers. Many of these fish were found dead in the trap net. It was suspected that most of the dead fish had died in the canal and drifted into the net. In 1997, only 11 suckers were caught in the trap net and age 0 suckers were extremely rare. It is likely that some suckers were missed when sampling during the poorest water quality period was discontinued (e.g., several weeks in August). A total of 90 suckers were captured on the debris reduction screens and on the AFA harvest screens in 1997. It is difficult to evaluate the juvenile and adult sucker data from the Cell Tech harvest facility because entrainment rates were primarily dependent on poor water quality and the collection of stressed and dying fish.

Reclamation has conducted salvage operations from Klamath Project canals receiving water from UKL annually since 1991. A summary of results from 1991-1995 was presented in the 1996 BA (USBR 1996a). Between 1996 and 1999, the numbers of suckers salvaged were 11,000 (1996), 2,400 (1997), 2,700 (1998), and 27,000 (1999) (USBR 2000b). Age 0 fish dominated the 1996, 1998 and 1999 salvage operations and age 1+ in 1997. Numbers of suckers salvaged from Klamath Project canals do not appear to be strongly correlated with age 0 sucker monitoring data in UKL (Simon et al. 2000b) or the fish entrainment data collected at the A-Canal headworks or Link River Dam diversion (Gutermuth et al. 2000a, 200b). The canal salvage data should probably be viewed as a qualitative index, since there are several factors that influence the numbers salvaged. Poor water quality conditions have been documented in several years that likely resulted in high mortality of canal fish (Gutermuth et al. 1998b). Rates of sucker entrainment may also be related to habitat conditions in UKL. During years with poor water quality (e.g., 1996) higher numbers may move out of the lake than years with good water quality (e.g., 1991, 1999). Varying levels of success in draining the canals and guiding suckers out of the canals into the Lost and Klamath Rivers may also affect the results. Additionally, only a small percentage of the canal system was sampled and electrofishing is very inefficient in the canals; the result is that large numbers of suckers were undoubtedly missed. Locations where concentrations of suckers are found vary from year to year and new sites with fish are found each year. Screening of A-canal in 2002 should markedly reduce the number of postlarval fish entrained.

Entrainment also occurs at other diversions in the system, but none have been studied as thoroughly as the A-Canal or Link River diversions. At Clear Lake Reservoir, a large barrier net has been

placed in the forebay since 1993 during the irrigation season to reduce entrainment. A 1-inch square mesh net was used from 1993-1998 and a ¾-inch square mesh net was used in 1999 and 2000. Based on end of season fish salvage from the dam outlet, the net placement appears to have been fairly effective in reducing loss of juvenile and adult suckers (USBR 2000b). However, following increased releases from Clear Lake in September 2000, many more suckers were salvaged even though new nets were in place in the dam forebay area. Reclamation salvaged 587 suckers in September and October 2000. This number is considerably larger than has been salvaged in previous years and indicates the need for a permanent screen. At Malone Dam, chicken- wire barriers (1-inch square mesh) were installed at the head end of the West Canal and East Malone Lateral in 1993 and replaced in 1994 and 1999. These barriers have been maintained by the Langell Valley Irrigation District. Only six age 0 suckers were salvaged from the West Canal in 1999 (USBR 2000b). At Agency Lake Ranch, Reclamation is using a ¼-inch delta mesh barrier net temporarily to reduce entrainment in 1998 and 2000. Reclamation monitored the effectiveness of the barrier net using a rotary trap in 2000. Nets and coarse-wire barriers for screening must be seen as temporary measures, and are not acceptable as replacements for properly designed and functioning screening which are not only engineered to reduce or eliminate entrainment, but also to minimize impingement.

The total entrainment estimates for A-canal and the two Link River canals approach the total population estimate of Age 0 suckers derived from targeted annual multi-gear sampling of UKL by OSU. The OSU Age 0 sucker population estimates for August 1997 and1998 were 82,477 and 665,421, respectively. The combined A-Canal and Link River entrainment indices for Age 0 suckers (<150 mm FL) in 1997 and 1998 were 64,368 (44,974 + 19,394) and 328,459 (24,5642 + 82,817) suckers entrained (Gutermuth et al. 2000a, 2000b), with most suckers caught in August and September. Increases in entrainment are associated with apparent declines in the lake populations. In both years UKL catches by OSU declined precipitously to below the entrainment values in September and October. Differences in gear and uncertainties of sampling efficiencies make it impossible to directly quantify the exact percent of young suckers produced in UKL that are ultimately entrained by the diversions. However, it is clear that entrainment itself accounts for a substantial component of the Age 0 juvenile mortality.

Effects of Pesticides Used on Klamath Project Lands

Pesticides and other agrochemicals are used on Project right-of-ways, in Project canals, and on private lands that receive Project water. Agricultural activities on these private properties are considered in this opinion to be interdependent or interrelated to the operation of the Klamath Project, as discussed in section entitled "Description of the Proposed Action," if the activities are dependent on Project water or if Project drains are used. The February 9, 1995, BO (FWS log # 1-7-95-F-26) provided incidental take coverage for use of the aquatic herbicide acrolein in Project irrigation canals operated by Klamath Irrigation District and Tulelake Irrigation District. That BO was amended on August 18, 1999 (FWS log # 1-10-99-F-103), to include canals operated by Langell Valley Irrigation District (LVID), when it was realized that LVID was not covered by the 1995 BO. Mosquito control in Project canals by the Klamath County Vector Control was also considered in the February 9, 1995, BO.

The effects of pesticide and fertilizer use on the Federal lease lands near the Tule Lake NWR, is covered by the February 9, 1995, BO and amendments.

Because pesticide use on Project rights-of-ways and canals has been consulted on, impacts to listed suckers and bald eagle should be minimized. However, we have insufficient information on pesticide use on private lands that use Project water or canals to address them in this BO. Therefore any take of LRS, SNS or bald eagle as a result of pesticide use on these lands will not be addressed in this BO. Until Reclamation provides us with information to the contrary, we consider pesticide use on private lands a potential threat to all three species. This threat is minimized when pesticides are used according to label instructions and adequate buffer strips are used adjacent to open water or canals.

Summary of Effects of the Proposed Action to LRS and SNS

Reclamation's proposed action, the operation of the Klamath Project, is likely to continue profoundly affecting LRS and SNS conservation status through loss and degradation of spawning, larval, juvenile, and adult rearing habitat and degradation of water quality related to regulation of water levels in reservoirs; fragmentation of sucker populations, increasing the risk of hybridization; blockage of passage; and massive entrainment of fish through Project diversions. These effects along with other cumulative effects will likely lead to significant mortality of suckers and retard recovery.

The greatest and most immediate threat posed by the proposed action is the potential exacerbation of already poor water quality conditions in UKL. The occurrence of three years of lethal water quality in the past decade suggests that similar events are very likely to occur again in the immediate future. Project irrigation diversions from UKL will reduce depths and likely further degrade current hypereutrophic conditions. Reduced lake levels will likely contribute to *AFA* bloom conditions through increased average water-column light levels and increased internal nutrient loading through chemical and physical mechanisms that are enhanced at lower lake levels. Reduced water depths will likely limit available DO levels because smaller water volumes contain less DO, and it will be consumed more quickly by water column and sediment bio-chemical processes.

Next in importance are greatly limited available habitat for all life-history stages, but especially larvae and adults, as a result of reduced depths caused by water withdrawals. Lower lake levels will likely restrict access to water quality refuge areas and confine adult suckers to small areas of the lake where they are more readily exposed to poor water quality, and disease and parasites will further stress them. The result of these adverse effects will likely be continued infrequent recruitment and significant loss of adults in periodic die-offs.

Additionally, a highly significant threat is entrainment of larvae and juvenile suckers into A-canal and Link River hydro-diversions. The documented level of entrainment at these three diversions likely represents a high proportion of the age 0 juveniles that occur in the lake in some years. These losses are likely to be in part responsible for the low frequency of year-class development that has been documented in UKL. Year class development needs to be of sufficient magnitude

and frequency to offset loss of adults by fish kills or else the population will continue to decline and recovery opportunities will be compromised.

Perhaps less likely to occur, but nonetheless a significant threat, is prolonged drought. The proposed action will not protect suckers from severe droughts and water withdrawals will only increase the frequency and magnitude of low water conditions. Even low intensity droughts could have severe effects in UKL where water quality conditions can be bad in all water-year types and where small changes in water depths can profoundly affect the amount and quality of the habitat. Although drought is primarily a threat to suckers in UKL because it may exacerbate water quality problems, suckers in other Project reservoirs are also at risk because of water quality problems, especially in winter under an ice cover.

In 1992 and 1994, the Service issued jeopardy biological opinions on the long-term operation of the Klamath Project because of severe adverse effects to LRS and SNS (Service 1992, 1994). Since then Reclamation has provided valuable scientific leadership, funding a wide variety of studies leading to a much improved understanding of UKL ecosystem management needs. However lake management continues to be a major threat to the suckers and other species in UKL. In 1997, Reclamation adopted the "low-range" UKL elevations, based on concerns and data presented by the Klamath Tribes. Managing UKL to the July 15th and September 30th elevations of 4141.6 ft and 4139.0 ft, respectively, have been the most significant management actions taken by Reclamation to protect LRS and SNS since the Project began operating nearly a century ago. Nevertheless, the proposed action calls for UKL levels below 4139 ft, even though recent scientific information indicates high risks to suckers associated with these low lake levels.

Reclamation has been assisting with restoration work in the UKL watershed and recently purchased the 15,000-acre Agency Lake Ranch. The Service has no doubts about the water quality benefits these actions are currently having and will continue to provide into the future. However, because of the current hypereutrophic conditions in UKL, and the potential role lake level has on water quality, it is crucial in the short-term that Reclamation manage lake levels in UKL to reduce the extreme risk to LRS and SNS posed by water quality.

Effects of the Action on Proposed Critical Habitat

The Klamath Project lies within or adjacent to all six of the proposed critical habitat units: CHU #1 (Clear Lake and Watershed); CHU #2 (Tule Lake); CHU #3 (Klamath River); CHU #4 (UKL and Watershed); CHU #5 (Williamson and Sprague Rivers); and CHU #6 (Gerber Reservoir and Watershed). Primary constituent elements likely to be adversely affected directly or indirectly with Reclamation's proposed actions for these units are as follows:

CHU #1- Clear Lake and watershed: reduced water quality, primarily low DO, both in summer and in winter below an ice cove, as a result of low lake levels; blocked access into Willow Creek, the single spawning tributary system at low lake levels; and providing enhanced habitat for non-native, predatory fish. Additionally the dam blocks access of downstream fish into Clear Lake and tributary spawning.

CHU #2 - Tule Lake: degraded water quality via increases in temperature, BOD, pH, ammonia, nutrients, pesticides, and sediments, and lowered DO; loss of spawning and rearing habitat in the Lost River; severe sedimentation in the Tule Lake sumps; population fragmentation; habitat improvements for non-native, predatory fishes; and changes in spawning flow magnitude and duration below Anderson-Rose Dam.

CHU #3 - Klamath River: alterations in flow timing, magnitude, and duration; establishment of non-native, predatory fishes; and water quality degradation including pesticides, and increased temperature, BOD, pH, ammonia, nutrients, and sediments, and lowered DO. Lack of fish passage causes population fragmentation, and peaking releases from downstream reservoirs likely adversely impact sucker spawning and subsequent larval/juvenile lifestage activities.

CHU #4 -UKL and watershed: reductions in water surface elevations has numerous potential direct and indirect affects to CHU #4's primary constituent elements. Of greatest concern are potential losses of shoreline spawning areas, young-of-the-year rearing areas of emergent vegetation, and loss of deep-water habitats and water quality refuges areas for older fish; water quality degradation, primarily increased pH and ammonia, and reduced DO; and segregation of habitats. Also there are concerns that lower lake levels will reduce conductivity between restored wetlands and UKL at the mouths of the Wood and Williamson Rivers. One of the major purposes of these wetland restorations projects was to reestablish this connectivity and provide lost habitat for age-0 suckers (A. Hamilton, BLM, pers. comm.).

CHU#5 -Williamson and Sprague Rivers. Most of this unit is unaffected by the proposed action; however, water level management and its associated impacts would adversely affect spawning access to the Williamson River, larval emigration and quality of rearing areas, and access to refugial areas.

CHU#6 - Gerber Reservoir and watershed: reduced water quality, primarily low DO, both in summer and in winter below an ice cove, as a result of low lake levels; blocked access into the reservoir and upstream spawning area; and providing enhanced habitat for non-native, predatory fish.

Conclusion Regarding Effects to Proposed Critical Habitat

Reclamation determined that the proposed action would not likely adversely affect proposed critical habitat. The Service does not concur, and instead determines that proposed critical habitat will likely be adversely modified. Our basis for this finding is as follows.

Water quality is the most crucial primary constituent element to proposed critical habitat (Service 1994a). Reclamation's proposed operations will likely lead directly or indirectly to water quality problems in Clear Lake (CHU #1), Tule Lake (CHU #2), Klamath River (CHU #3), UKL (CHU #4), and Gerber Reservoir (CHU #6), as has been described above. Water quality is likely to be severe in UKL and sedimentation in Tule Lake will block access to upstream spawning areas and will eventually make the sumps too shallow for suckers.

Physical habitat will be adversely affected by the proposed action through water elevation manipulation in Clear Lake (CHU #1), Tule Lake (CHU #2), Klamath River (CHU #3), UKL (CHU #4), and Gerber Reservoir (CHU #6). Possible impacts to this primary constituent element include reduction in fish passage; loss or degradation of littoral shoreline vegetation used by age 0 suckers; and reductions to available deepwater habitat and potential blockage to water quality refuge areas at lower lake levels.

Biological environment will be adversely affected by the proposed action through a number of mechanisms. This is especially a concern in UKL (CHU#4), where the ecology of the system is so highly altered by hypereutrophic conditions that are exacerbated by lake-level management. The proposed low lake levels < 4140 ft are likely to benefit *AFA* growth with associated water quality problems. Poor water quality will likely be stressful or lethal to suckers. Stressful conditions will likely lead to increased incidences of disease and parasites. Enhancement of non-native fish populations that both prey on and compete for food with LRS and SNS may also be a concern.

4.0 CUMULATIVE EFFECTS

Cumulative effects are those effects of future non-Federal (State, local governments, or private) activities on endangered and threatened species or critical habitat that are reasonably certain to occur within the action area of the Federal activity subject to consultation. Future Federal actions are subject to the consultation requirements established in section 7 and, therefore, are not considered cumulative to the proposed action.

Clear Lake Watershed

Most of the land in the Clear Lake watershed is Federally-owned; Federal actions affecting listed species will undergo section 7 consultation and are not considered further in this section. Remaining land is in private ownership and is mostly open juniper-bunchgrass rangeland with small numbers of ponderosa pine. Few people live in the area. The Service anticipates that most of this land will be used as it has in the past as range- and forest-land.

Grazing

Grazing, as currently practiced in the Clear Lake watershed, is not considered by the Service to be a significant threat to suckers. Limited areas of private rangeland are located in the Clear Lake watershed, often in key riparian and wetland areas. The adverse effects of grazing on water quality was discussed previously. Grazing in the Clear Lake watershed has previously destabilized streambank vegetation, resulting in erosion, siltation, reduced quantities and quality of gravel spawning areas, increased water temperatures, caused wider and shallower stream channels, and lowered water tables (Modoc National Forest 1991). The Water Users Plan (Klamath Basin Water Users Protective Association 1993) suggests that significant opportunities exist to improve riparian habitat in the Clear Lake/Lost River/Gerber Reservoir drainage. Condition of rangelands is anticipated to continue to improve with proactive management.

Forestry

Forestry practices may also contribute to water quality declines in the upper Lost River Basin. However, because commercial forest comprises such a small area and will be infrequently harvested, the Service does not consider forestry in the Clear Lake watershed to be a significant threat to LRS and SNS.

Introduced Fishes

Introduced fishes such as brown bullhead, fathead minnow, Sacramento perch, yellow perch, pumpkinseed, green sunfish, bluegill, crappie, largemouth bass, and brown trout have been accidentally or intentionally introduced in the Lost River Basin. Because, relatively stable sucker populations co-exist with abundant non-native fish populations in Clear Lake, the Service does not consider exotic fish to be a current threat there.

Other Effects

The Service is unable to identify other potential threats. Transportation of hazardous materials along roadways in the Clear Lake watershed is considered to be a minor threat owing to infrequent presence in the watershed.

Gerber Reservoir Watershed

Private Water Developments

There are six private water developments in the Gerber Reservoir watershed (USBR 1970c). These developments are primarily for livestock operations. Approximately 13,300 acres of both privately held and Forest Service permitted land are included in these developments. Each of these operations use a combination of dams, reservoirs, and ditches to distribute water or use dikes, ditches and canals to irrigate their lands. Use of these water rights are primarily for pasture and hay, and grain cultivation.

The effects of these impoundments on the LRS and SNS populations in Gerber Reservoir watershed are unknown. During periods of above-average precipitation SNS are known to occupy some of these impoundments. Water storage may increase instream flows during the summer. The impoundments also may trap sediments keeping them out of downstream pools and runs where SNS reside or spawn. However, water stored in these reservoirs from spring flows may decrease instream flows necessary for SNS spawning migrations, such as in Bell Hall Creek (A. Hamilton, BLM, pers. comm.). BLM is currently developing a watershed analysis which addresses the effects of these diversions (A. Hamilton, BLM, pers. comm.).

Other Effects

Land use in the Gerber Reservoir watershed is similar to that of Clear Lake, perhaps with more commercial timber on private lands. Forestry and grazing that follow established best management practices are not considered to be a significant threat to SNS in the Gerber Reservoir watershed.

Lost River and Tule Lake Sumps

The Tule Lake sumps are affected by adjacent land uses and upstream water quality in the Lost River. The Service anticipates that Refuge lease lands will contribute nutrients, sediment, and pesticides to the Tule Lake sumps which will adversely affect listed suckers. Pesticide and fertilizer use on the lease lands has undergone section 7 consultation and therefore it is not considered here. The indirect effect of sediments from the lease lands has not been consulted on, nor have sediment effects been considered as an indirect result of Klamath Project operations.

The Service anticipates that private lands on the Lost River will contribute nutrients, sediment, and pesticides to the Tule Lake sumps which will affect listed suckers. Some/many of these lands receive water from the Klamath Project. These interdependent effects are considered part of effect of the action discussed above. Effects of other private actions are considered cumulative effects. However, the Service has no information to determine which effects are interdependent or interrelated to the proposed action, since Reclamation's BA does not address these effects. Until Reclamation provides the Service with this information, the Service must assume that all adverse impacts to listed species in Tule Lake sumps as a result of upstream water quality impacts are indirect, interdependent or interrelated to the proposed action.

Upper Klamath Lake Sub-Basin

Private landowners along streams tributary to UKL annually exercise their State of Oregon rights to withdraw water for irrigation and livestock watering. The total amount of water that is annually withdrawn before it reaches UKL has not been determined but is substantial. It is estimated that about 186,000 acres benefit from diversions. Total off stream diversion equals about 400,000 ac-ft from UKL tributaries (Sprague River = 87,000 ac-ft, Williamson 85,000 ac-ft, and Wood River 224,000 ac-ft [Broad and Collins 1996]). Nutrient enriched return flows from these upstream agricultural lands coupled with the reduced inflows to the lake (about 170,000 ac-ft), because of irrigation depletion, likely contribute to the eutrophication in UKL. The resulting lowered water level and poor water quality may affect all three listed species considered in this BO.

Despite high background P levels in UKL tributaries and springs (Kann and Walker 1999; Rykbost 1999, 2001), data exists from several studies to indicate that P loading and concentrations are elevated substantially above these background levels (Miller and Tash 1967; USACE 1982; USBR 1993a, 1993b; USGS Water Resources Data 1992-1997; Kann and Walker 1999; Eilers et al. 2000). One of the earliest nutrient loading studies (Miller and Tash 1967) indicated that, despite accounting for only 12% of the water inflow, direct agricultural input from pumps and canals account for 30% of the annual external total phosphorus budget. Other studies show that drained and diked wetlands consistently pump effluent containing 2-10X the phosphorus concentration of tributary inflows (USBR 1993a, 1993b), and that nitrogen and phosphorus are liberated from drained wetland areas, leach into adjacent ditches, and are subsequently pumped to the lake or its tributaries (Snyder and Morace 1997). Coupled with the considerable but diffuse non-point contribution stemming from wetland loss, flood plain grazing, flood irrigation, and channel degradation, the TP input from anthropogenic sources likely accounts for a far greater percentage than that indicated by the 30% contributed due to direct pumping alone. Gearheart et al. (1995)

estimated that over 50% of the annual TP load from the watershed could be reduced with management practices, and Anderson (1998) likewise estimated that in-lake TP concentration could be reduced by utilizing watershed management strategies. Walker (1995) also estimates that an increase in Agency Lake inflow concentration from approximately 80 to 140 ug/l (40%) is due to anthropogenic impacts.

The Williamson River and Wood River together accounted for 67% (48% and 19%, respectively) of the 1992-1998 total phosphorus load, with springs and ungaged tributaries contributing another 10%. Precipitation, Sevenmile Canal and agricultural pumping accounted for the remaining 23% (Kann and Walker 1999). Unlike water contribution, where Wood River, Sevenmile Canal, and Pumps contribute 25% of the water load, these same sources contributed 39% of the average annual TP load. In contrast, springs contributed 16% of the water input, but contributed only 10% of the TP load. This appears to be partially due to the consistently higher volume weighted TP concentration occurring in the pump effluent, and Wood River and Sevenmile canal systems.

The estimated anthropogenic contribution of TP loading for all 7 water years is 40%, with a range of 36 to 45% for individual years. These values are very similar to the 40% anthropogenic TP contribution estimated by Walker (1995) for Agency Lake.

TP loads during the 1992 and 1994 drought years were 62% of the 1992-1998 average. The 1993 water year is of note because while flow was 108% of the 7-year average, TP load was 114% of the average. Other years (with the exception of 1996) tended to have percentage of average TP loads lower than their respective percent of average water inputs. It seems likely that more sediments and associated nutrients are flushed downstream following droughts because sediments are not flushed downstream until flows are high. Moreover, the volume weighted TP concentration of the Sprague River in 1993 is higher than any other year, indicating additional watershed contributions of TP. Because the Sprague River watershed is impacted by wetland and riparian loss, flood plain grazing, agricultural practices, and channel degradation, it would be prone to TP export, especially during major runoff events.

An estimate of the particulate phosphorus (PP) load was taken as the TP load minus the SRP (soluble reactive phosphorus) load. These data clearly show an increase in the loading of PP during high runoff events for the Williamson and Sprague Rivers. During these high flow events, which typically occur from January-May, PP can increase to 60% of the TP load, compared to less than 5% during summer low flow periods. There are also noticeable spikes of PP load occurring in the Wood River and Sevenmile Canal systems, but they are not limited to high runoff periods. This pattern could be consistent with flood irrigation practices that would tend to be pulsed in nature, and where overland runoff could increase the proportion of particulates. The increase in PP loading is indicative of degraded watershed conditions, since particulate P is usually bound to clay particles. In a healthier watershed (e.g., intact riparian areas and flood plains) the concentration should tend to decrease at high flows through dilution, and particulate loading should only increase slightly (Kann and Walker 1999).

Eiliers et al. (2000) using paleolimnology techniques examined nutrient content of UKL sediments over the past 1000 years. Based on a variety of analyses they determined that sediment

accumulation rates and levels of phosphorus in sediment have increased significantly in the past 150 years. They attributed these increases to anthropogenic, watershed effects, such as forestry, agriculture, and grazing. Their results were consistent with those of Coleman and Bradbury who found increased amounts of tephra (volcanic ash) in recent UKL deposits, suggesting increased upland erosion rates (USGS unpub.data).

Agency Lake and Wood River Basin

Numerous farms and ranches in the Fort Klamath area divert significant quantities of water out of the various streams and springs in the watershed upstream and adjacent to Agency Lake north of UKL. The natural streams in this area include: Sevenmile Creek, Fourmile Creek, Annie Creek, the Wood River, and Crooked Creek. Additionally, water from various natural springs is diverted to various maintained ditches which supply irrigators in the area. Major ditches conveying water from the natural creeks and springs to the irrigators include: Bluespring, Threemile, Fourmile, Sevenmile, and Melhase Ditches. Return flows from these ditches are collected into several canals which connect with and are adjacent to Agency Lake. These canals contain water year round and include: West, Sevenmile, Central, and North canals among others.

The Meadows Drainage District and many individual landowners divert water through the aforementioned ditches. A more detailed description of these diversions is given in Reclamation's 1992 BA (USBR 1992a).

Juvenile Lost River and SNS are known to occur in the Wood River and Crooked Creek, (D. Markle, OSU, pers. comm.). It is suspected that some of these sucker species may be spawning in these tributaries to Agency Lake. In larval distribution and abundance studies at the confluence of the Wood River and Agency Lake in 1991, investigators collected larval suckers, indicating that suckers were using the Wood River drainage for spawning habitat (Markle 1992). Depending on how far these spawning fish migrate upstream in the Wood River and Crooked Creek, the adult spawners, embryos, and emerging larvae of these suckers may be impacted by water diversions from these tributaries. If spawning suckers are in downstream reaches of the Wood River and Crooked Creek below the irrigation diversions when water deliveries to the ditch systems are diverted out of the channel, then the spawning behavior of these fish may be disrupted, resulting in no sucker spawning in that year.

In 1991, Markle (1992) found that larval suckers were emigrating through the lower Wood River into the confluence with Agency Lake in late July. This corresponds to the approximate peak of water diversion (June-mid August) from the Wood River and Crooked Creek. Therefore, if suckers succeed in spawning within the reaches downstream of the ditch diversions, the embryonic and emergent life-stages would potentially be subject to diversions into canals and fields, reduced flows, and resulting elevated water temperatures during incubation and larval emigration.

In addition to the potential direct impacts on sucker populations of the diversion of water into the irrigation ditches upstream of Agency Lake, potential indirect impacts of these diversions are possible. As was previously noted, a large portion of the water diverted to the irrigation ditches is recovered to the ditches as return flows.

Depending on land practices, use of agrochemicals, the number of reuses, and erosion in the agricultural area, the water quality (including DO, turbidity, ammonia, and temperature) of these return flows could range from fair to extremely poor. The return water, upon collection in the downstream canals, could then potentially impact the water quality of the marsh and near-shore habitats of larval, juvenile, and or adult suckers or other fishes present. It is known that young life stages of suckers frequent these and other habitats types in UKL. Vincent (1968) found that approximately 80 percent of suckers sampled in his study areas were collected in either marsh or rocky shoreline habitat as compared to mid-lake sampling locations. Vincent (1968) determined that of approximately 20 miles of shoreline habitat in Agency Lake, 9.5 miles were marsh shoreline habitat. Markle (pers. comm.) found that Agency Lake was devoid of larval or young-of-the-year suckers after late summer. The inability to collect larval suckers indicates that the larval suckers sampled at the Wood River confluence earlier in the summer had either: (a) migrated out of Agency Lake; (b) were recruited into the Lake at such low levels that their abundance was minimal and could not be detected by sampling; or (c) not survived in Agency Lake after mid-summer. Nutrient rich irrigation return water reaching Agency Lake could result in *AFA* blooms and anoxic conditions within Agency Lake itself. These noxious blooms and resulting degraded water quality could potentially result in fish kills in Agency Lake during the late summer months.

Williamson River Watershed

In the upper Williamson River watershed, grazing and forestry has adversely affected stream morphology, with the result that the river is entrenched. Agricultural practices in the drainage could have the same effects as those listed above for the Agency Lake drainage. Unscreened irrigation diversions on the lower Williamson River in the area of concentrated larval migration and rearing may be reducing sucker recruitment to UKL. Irrigation diversions also reduce stream flows.

Sprague River Watershed

Chiloquin Dam

Chiloquin Dam, located just upstream of the Sprague River's confluence with the Williamson River, is estimated to have eliminated more than 95% of the potential spawning habitat for the LRS and SNS and is considered one of the more significant reasons contributing to the decline of the suckers (Service 1987, 1988). Although the dam has a fish ladder, the dam has previously been considered as an almost total barrier to the annual spawning migrations for the endangered suckers (Stern 1990); however, more recent data shows that a substantial number of suckers may use the ladder, although information pertaining to passage success is not currently available (R. Shively, pers. comm. 2001).

Partial blockage of the suckers at the Chiloquin Dam during their upstream spawning migration may force suckers to spawn in the short river reach immediately downstream of the dam. Spawning of multiple related species within a relatively confined area may cause hybridization, although this has not been confirmed. LRS and SNS have been observed spawning together below Chiloquin Dam (L. Dunsmoor, pers. comm.). Spawning and rearing habitat in reaches

downstream of the dam are very likely limited. In addition, mass spawning of the suckers in confined areas close to UKL may create adverse density-dependent conditions limiting recruitment of larval suckers (e.g., competition for limited food supply and rearing habitat in confined areas of the lower Williamson River). If existing limited fish passage conditions at Chiloquin Dam persist, it will very likely restrict recovery efforts for the endangered suckers.

Agricultural Impacts

Spawning habitat in the Sprague has been degraded by channelization, sedimentation, increased water temperatures, high nutrient concentrations, and the resulting growth of periphytic AFA and aquatic macrophytes. These problems originate in the Sprague River Valley, upstream of the present-day spawning areas, where agricultural activities have degraded the riparian habitat. In addition to the resulting loss of spawning habitat, the Sprague River is a major contributor of excess nutrients to the hypereutrophic UKL. Long-term success of spawning habitat restoration efforts in this river system depend almost entirely on rehabilitation of the upstream reach of the Sprague River (Service 1992).

Effects of Diversions Upstream of UKL

Water diversions and pumping of groundwater in the UKL watershed affect suckers by reducing flows into UKL, thus reducing lake levels and water quality. Reduced flows from the upper Williamson River would affect input of humic substances into the lake. Humic substances are believed to inhibit *AFA* growth. Reduced flows from the Wood River and west-side streams such as Sevenmile Creek, as a result of diversions, also likely lead to reduced input of humics.

One potentially significant water diversion on the west side of the UKL watershed, above Link River, is the Cascade Canal. Here water is diverted from Fourmile Lake into the Rogue River basin. The dam at the outlet of Fourmile Lake was built in 1922. About 6,100 ac-ft (range = 1,200 - 11,500 ac-ft) are diverted annually from Fourmile Lake via Cascade Canal to Fish Lake, where the water is used by Reclamation's Rogue River Basin Project. (Tarbet 2001). Annual flows to the headwaters of Fourmile Creek are estimated to be reduced by 6,100 ac-ft, from 8,000 to 1,900 ac-ft, mostly from April to July. Without regulation, the average flow of Fourmile Creek into UKL would be <10,000 ac-ft.

The effect of diversion of flows from Fourmile Creek to the endangered suckers is unclear. Assuming that about 5,000 acre-ft are actually lost to UKL as a result of the out-of-basin diversion, this is an insignificant amount compared to the estimated >1 million acre-ft inflow. However, a more accurate comparison would be made by comparing the loss to the flows and discharges of the springs and minor creeks flowing into UKL which is about 26,000 acre-ft. In this comparison the 5,000 acre-ft loss would represent about 20% of inflow. Further, this loss could be significant to suckers since it would be occurring in the Pelican Bay area, a known water quality refuge area for suckers. However, since most of the flow is in May and June, it would not have much effect to water quality refuge areas which are important to suckers in July and August. Suckers once used Fourmile Creek for spawning but no longer do so. It is unknown if this is related to flow reduction in Fourmile Creek.

Klamath River

Agricultural Diversions

Agricultural (irrigation) diversions from the main stem of the Klamath River upstream of Copco Reservoir #1 and the California-Oregon border provide water to private landowners through a lease of water rights (Beak Consultants 1987). While these structures are relatively large, they probably do not impede fish passage in this river reach (Shrier, PacifiCorp, pers. comm.). More detailed information about these diversions are given in the biological assessment (USBR 1992a). The timing, volume, and the pattern of use of these irrigation diversions as well as their impact, (if any) on sucker populations are unknown, although impacts due to water quality and entrainment are likely.

Other Sources of Potential Impacts

Water quality on the main stem of the Klamath River upstream of the Keno Regulation Dam can at times be degraded due to treated sewage, storm water and non-point source runoff from the City of Klamath Falls. Lumber mills along the Klamath River near Klamath Falls also contribute to water quality problems in the river. The impoundment of the nutrient rich waters in the reservoirs are known to contribute to *AFA* blooms within the reservoirs and cause downstream AFA nuisance conditions in the river (Klamath River Basin Fisheries Task Force 1991). The nutrient loads in these reservoirs and the river are known to be elevated, with 79 percent of the nitrogen and 68 percent of the phosphorus in the Klamath River coming from sources upstream of the Iron Gate Dam (CDWR 1986, as cited by The Klamath River Basin Fisheries Task Force 1991).

Except for natural erosion along the banks of the Klamath River, there appear to be no other major source of sediment input to the Klamath River below Keno. The river reach below the J. C. Boyle Dam in Oregon to the California border was designated as the Klamath Scenic Waterway in 1988. The subsequent reach below the state line to the Copco Reservoir is designated "Wild Trout Waters" by the CDFG (The Klamath River Basin Fisheries Task Force 1991).

4.2 Other Cumulative Effects

The transportation of hazardous materials by truck and train along the eastern and southern margin of UKL and over tributaries could result in spills and negative impacts to the listed and unlisted species in the basin's waters. AFA and *Daphnia* harvesting in UKL may result in the take of larval and juvenile suckers. The use of chemicals such as pesticides, herbicides, and mosquito or "midge" control chemicals could result in negative impacts to listed species throughout the basin. The diversion of water directly from UKL by private (non-Project) water users may result in the taking of suckers and reduction of habitat.

Restoration Activities

Approximately 15,000 acres of drained wetlands around UKL are being restored. The immediate

benefit from these lands is that management will emphasize water quality improvement. Management actions on these lands that once contributed nutrients to UKL have been stopped or significantly reduced. Restoration on the Running Y Ranch Resort has included up to 1000 acres of marsh habitat. Other activities likely to occur include extensive riparian restoration along the major tributaries of UKL through fencing and improved grazing practices, and wetland restoration. The Nature Conservancy (TNC) and other partners recently purchased Tulana and Goose Bay Farms, totaling 8000 acres at the mouth of the Williamson River. Acquisition and restoration of this property has great potential for restoring sucker habitat and improving water quality in UKL. TNC has also purchased an additional 7,000 acres at Sycan Marsh, expanding its preserve to over 25,000 acres. This acquisition and restoration of the Marsh should improve water quality and hydrologic function in the Sycan and Sprague Rivers, tributaries to UKL. Other restoration projects are underway by ODFW and by private land owners. Restoration of aquatic habitats and uplands to improve watershed function will be essential for recovery of the suckers and other aquatic species. Such activities also will increase stream flows, raise the water table in pastures, increase wildlife habitat, and have other general benefits. Walker (2001) states that some improvement in water quality has already been detected since TP levels in UKL have been reduced by about 10% in the past decade. If anthropogenic phosphorus can be cut another 20 to 40%, it is anticipated that water quality in UKL will significantly improve.

5.0 CONCLUSION

After reviewing the current status of the LRS and SNS, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological and conference opinion that implementation of the Reclamation's operation plan for the Klamath Project is likely to jeopardize the continued existence of the LRS and SNS and adversely modify their proposed critical habitat. The Service reached these conclusions for the following reasons:

At Upper Klamath Lake, implementation of the action, as proposed, is likely to:

1. Significantly increase the loss of larval and juvenile sucker habitat at critical phases of their life cycle which will reduce the frequency and magnitude of year-class development;

2. Significantly increase the loss of all life stages, but especially larvae, through entrainment;

3. Block passage of suckers into areas of preferred habitat or to spawning areas which will reduce their survival and reproduction;

4. Increase the frequency and magnitude of potentially lethal water quality conditions by lowered lake levels which will optimize light and nutrient conditions that will facilitate algal blooms. These blooms adversely affect the survival of all life history stages of the suckers, and the reproduction of adults;

5. Contribute to poor water quality conditions during algal decay cycles by reducing lake volume/surface ratios that influence dissolved oxygen concentrations. These conditions will adversely affect the survival of all sucker life history stages, but will especially reduce the

number of adults, and limit their longevity and reproductive potential;

6. Contribute to the loss of or reduction of access of suckers to water quality refuge areas that are critical to ensure adult sucker survival; and
7. Reduce lake volume/surface ratios during winter ice-cover conditions that influence dissolved oxygen and un-ionized ammonia concentrations which will contribute to potentially lethal water quality conditions that could adversely affect adult and juvenile survival.

At Clear Lake, Gerber Reservoir, and the Tule Lake sump, implementation of the action, as proposed, is likely to:

5. Block passage of suckers into areas of preferred habitat or to spawning areas in Clear Lake and the Tule Lake sump, which will reduce sucker survival and reproduction;

6. Reduce water volume in summer and fall when water temperatures and respiration rates are high and lead to stressful/lethal conditions for suckers, and also make them more vulnerable to disease and predators; and

7. Reduce water volume/surface ratios during winter ice-cover conditions that influence dissolved oxygen concentrations and un-ionized ammonia will contribute to potentially lethal water quality conditions that are likely to reduce adult and juvenile sucker survival.

Collectively, these effects are likely to appreciably reduce the survival and recovery of the suckers and preclude the conservation needs of these species from being met, and appreciably diminish the value of critical habitat constituent elements essential to the conservation of the suckers.

6.0 REASONABLE AND PRUDENT ALTERNATIVES

Regulations implementing section 7 define reasonable and prudent alternatives as alternative actions identified during formal consultation that: (a) can be implemented in a manner consistent with the intended purpose of the action; (b) can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction; (c) are economically and technically feasible; and (d) would avoid the likelihood of jeopardizing the continued existence of listed species or result in the destruction or adverse modification of critical habitat (50 CFR 402.02). A reasonable and prudent alternative (with 8 elements) with respect to the proposed operation of the Klamath Project is as follows:

1. *Maintenance of Minimum Surface Elevations in Upper Klamath Lake*

Reclamation shall not divert water from UKL for irrigation purposes if surface elevations are anticipated to go below 4141.0 ft on January 1, 4141.5 ft on February 15, 4142.0 ft on March 15, 4142.5 ft on April 15 and June 1, 4141.5 ft on July 15, 4141.0 on August 15, 4140.5 ft on September 15, and 4140.0 ft on October 15, regardless of inflow year type.

Reclamation shall formally notify the Service as to how it will ensure that these levels will not be violated owing to gage error or malfunction, such as occurred in 2000. Reclamation shall be responsible for verification that UKL water level readings are accurate, at least to 0.05 ft.

Implementation of the Project with these minimum elevations is necessary to avoid jeopardy and adverse modification of proposed critical habitat for the following reasons:

A. Minimum surface elevations of 4141.0 ft on January 1, 4141.5 ft on February 15, 4142.0 ft on March 15, and 4142.5 ft on April 15 are necessary to provide adequate water depth in shoreline spawning habitat along the UKL eastern shore from February-May to ensure adequate development of LRS and SNS year classes. Suckers that spawn along the east shore of UKL represent a unique population that must be maintained to allow for survival and recovery of both LRS and SNS. Year-class development is essential to provide for future generations of suckers as adults die from fish kills, predation, or from other factors. These minimum surface elevations will provide adequate spawning habitat which constitutes a primary constituent element of proposed critical habitat. In this way, operation of the Project will provide, in part, for functional critical habitat.

B. Minimum surface elevations of 4142.5 ft on April 15 and June 1, 4141.5 ft on July 15, and 4141.0 on August 15 are necessary to provide adequate water depth in emergent vegetation habitat in the lower Williamson River and in UKL for larval and juvenile suckers to ensure adequate year-class development. Emergent vegetation habitat is critical for survival of larval and juvenile suckers which are essential to provide for future generations of suckers as adults die from fish kills, predation, or from other factors. These minimum surface elevations will avoid jeopardy and adverse modification of proposed critical habitat, in part, by providing adequate rearing habitat where young suckers feed and avoid predators.

C. Minimum surface elevations of 4142.5 ft on June 1, 4141.5 ft on July 15, 4141.0 on August 15, 4140.5 ft on September 15, and 4140.0 ft on October 15 are necessary to maintain adequate water depths in UKL to reduce the magnitude and frequency of fish kills resulting from lethal water-quality conditions as a result of algal blooms occurring between June and October. If the frequency and magnitude of the fish kills are not reduced LRS and SNS populations will decline and reproduction will be reduced. Without adequate adult survival and reproduction, extirpation of UKL populations is likely to occur due to a reduction in individuals of sufficient age (up to 10 years for LRS) to spawn, which are essential for long-term survival and recovery of the species.

   Implementation of the Project with these minimum surface elevations will avoid jeopardy, in part, by reducing the frequency and magnitude of fish kills involving the LRS and SNS and provide for a diverse year-class population structure that will be more resilient to stochastic events. Maintenance of good water quality will provide for adequate functioning of one of the primary constituent elements of proposed critical habitat.

D. Minimum surface elevations of 4141.5 ft on July 15, 4141.0 on August 15, 4140.5 ft on September 15, and 4140.0 ft on October 15 are needed to maintain adequate water depths in

water quality refuge habitat in Pelican Bay-Fish Bank areas in UKL from July to October to protect adult suckers from the lethal effects of adverse water quality conditions as a result of algal blooms. By ensuring adequate water depths in this refuge area, it will allow some suckers to find good water quality during periods when lethal water quality conditions exist over most of UKL. Without adequate adult survival, which is essential for survival and recovery of these species, extirpation of UKL sucker populations is likely to occur.

Implementation of the Project with these minimum surface elevations will avoid jeopardy, in part, by reducing the numbers of adult suckers that die in water quality-related fish kills and provide for a diverse year-class population structure that will be more resilient to stochastic events. Maintenance of good water quality will provide for adequate functioning of one of the primary constituent elements of proposed critical habitat.

E. Minimum surface elevations of 4140.0 ft on October 15, 4141.0 ft on January 1, 4141.5 ft on February 15, and 4142.0 ft on March 15 are needed to maintain adequate water depths in UKL to reduce risk of lethal water quality under ice-cover conditions from December to March to protect juvenile and adult suckers. High lake levels in October will ensure that adequate levels of dissolved oxygen (DO) will be present in the water column once UKL freezes in November or December. High water levels during freeze-up (generally November to March), will ensure adequate DO to support adult and juvenile suckers in winter when DO is decreased by sediment oxygen demand and an ice cover prevents atmospheric reaeration. These higher lake levels will also dilute and toxic un-ionized ammonia that might also build up under ice cover conditions when mixing is reduced. Without adequate winter survival, extirpation of these populations, which are essential for survival and recovery of these species, is likely to occur. These minimum surface elevations are also necessary to ensure there is some year-to-year carryover of water to address, in part, drought conditions. Carry-over will help maintain UKL elevations in critically-dry years when inflow might be inadequate to do so.

Implementation of the Project with these minimum surface elevations will avoid jeopardy, in part, by reducing the numbers of adult and juvenile suckers that die during the winter when UKL is covered by ice and oxygen is not reaching the water column, will help dilute un-ionized ammonia which becomes more toxic at lower temperatures, and will help maintain adequate depths during droughts; this will provide for a diverse year-class population structure that will be more resilient to stochastic events. Maintenance, in part, of adequate water quality will provide for adequate functioning of one of the primary constituent elements of proposed critical habitat.

2. *Operation Plan for Low Water Year*

The Service has determined that a minimum surface elevation of 4140 ft in UKL, as set forth in RPA component 1 above, is necessary to avoid Project effects that jeopardize the suckers and and adversely modify their proposed critical habitat. However, the Service anticipates there will be low water years where inflow is inadequate for Reclamation to meet both RPA component 1 and NMFS's RPA requirement for Klamath River flows downstream for the threatened coho salmon. When Reclamation anticipates, based on the best available information (e.g., the April 15, NRCS

forecasts and associated model output), that it will be unable to satisfy RPA component 1 and requirements for Klamath River flows for coho salmon, this RPA component 2 shall be implemented.

The coordination procedures set forth below outline the method by which FWS and NMFS shall develop a plan that will best satisfy the requirements of listed species in low water years where inflow is inadequate to satisfy both RPA component 1 and Klamath River flows downstream for the coho salmon. Reclamation shall incorporate the plan developed by FWS and NMFS into the Project operation plan for a low water year.

Coordination Procedure for Low Water Years:

1. Data Collection, Dissemination, and Analysis

A. Reclamation shall provide FWS and NMFS with a projection of total available water in all Project lakes and reservoirs; this total will identify total available water for satisfaction of RPA component 1 and Klamath River flows downstream for coho salmon; and

B. Reclamation, FWS, and NMFS shall provide and use current data and information to determine the status of listed species.

2. Coordination Between Federal, Tribal, and Other Parties

Representatives from Reclamation, FWS, and NMFS shall coordinate with representatives from USGS, OSU, ODFW, CDFG, BIA, affected Tribes, and other parties, as appropriate, to consider and discuss available options for Project operation during a low water year that maximize implementation of RPA components for FWS and NMFS listed species. FWS and NMFS shall consider the results of this discussion when the agencies coordinate to determine how to best satisfy RPA component 1 and Klamath River flows downstream for the coho salmon in order to best protect each listed species.

3. FWS and NMFS Coordination

FWS and NMFS shall coordinate to determine how to best satisfy RPA component number 1 and Klamath River flows downstream for the threatened coho salmon, and how to best protect each listed species. The agencies shall employ a risk analysis process to be concluded in no more than two or three days during which the following factors shall be considered:

A. Data collected, disseminated, and analyzed during step 1 of this Coordination Procedure;

B. Results of discussions with Federal, Tribal, and other parties;

C. Minimum UKL surface levels required by RPA component 1 and NMFS's RPA

requirement for Klamath River flows downstream for the threatened coho salmon;

D. Current status of affected listed species, including:

1. Location, size and movement of young-of-the-year and juvenile fish;

2. Water quality in Project lakes and reservoirs and Klamath River below IGD in relation to anticipated water supply; and

3. Other risk factors, such as status of *AFA* blooms and potential DO demands; observed or anticipated fish kills; presence of pathogens; anticipated discharges of UKL springs that could affect water quality refuge areas; and any other relevant factors.

E. Implementation of emergency contingency measures to avoid impending extirpation or extinction for each listed species:

1. For suckers: FWS, NMFS, BOR, and other relevant Federal and State agencies and Tribes, potentially including USGS, ODFW, CDFG, and BIA, will immediately convene to determine most appropriate course of action, relating to: (1) adverse water quality most likely to occur between July and October resulting from low DO levels; and (2) lake and reservoir levels below those minimums specified in RPA component 1 likely to occur between September and October. Potential ways to improve DO levels to be considered include: oxygenation, aeration, and artificial mixing. Reclamation, in coordination with the Service and the agencies listed above, should develop a plan by August 2001 to use the best method to increase DO levels for each project lake and reservoir that can be immediately implemented should that need arise. Ongoing water quality monitoring in Project lakes and reservoirs (see RPA component 3 and RPM 4) will provide advance warning that DO levels are reaching levels where corrective action will be necessary.

2. Reclamation shall coordinate with the Service to ensure that a salvage plan for each reservoir is available for implementation by August 2001 should that become necessary to salvage suckers and move them to secure areas. Supplemental oxygenation, aeration, or mixing may be needed to minimize risk of hypoxia.

4. FWS and NMFS Coordination with Reclamation

FWS and NMFS shall provide, in writing, the results of the coordination and risk analysis process to Reclamation with detailed instructions regarding measures that must be implemented to best protect each listed species.

Results of Implementing the Coordination Procedure for 2001

In March 2001, Reclamation informed the Service that water supplies were inadequate to satisfy RPA component 1 and NMFS's RPA requirement for Klamath River flows downstream for the threatened coho salmon. Consequently, the Service and NMFS implemented the coordination procedure described above.

As a result of implementing the Coordination Procedure, the Service determines that, based on the available water supply for 2001 identified by Reclamation, a deviation from the required minimum surface elevation of 4140 ft in UKL under RPA component 1 is warranted in order to address the conservation needs of both suckers and coho salmon during this low water year so long as the minimum surface elevation of 4140 ft in UKL is sustained on a long-term basis. In addition, the Service and NMFS may direct implementation of the contingency measures identified as a result of this Coordination Procedure in order to ensure that long-term viability of the species are maintained.

The information considered during this Coordination Procedure is presented in Appendix 2 of this BO, along with the specific instructions for allocating available water supplies.

3. *Adaptive Management through Water Quality Monitoring and Reporting*

Reclamation shall, in coordination with the Service, plan and implement a water-quality/algal growth and nutrient cycling study/monitoring program for UKL that will provide information to be used by Reclamation to manage UKL. The plan shall focus on factors such as how lake levels affect: AFA growth, light availability, internal nutrient loading, DO levels, and how DO levels are affected by sediment DO demand during the summer and below an ice cover.

Because of the highly technical nature of these physical/chemical/biological interactions, and consistent with available funding, Reclamation, in cooperation with the Service and the U.S. Geological Survey (USGS), if available, shall convene a scientific review panel comprised of recognized experts in the field of freshwater primary production, especially scientists that have worked with algae, and nutrient cycling in shallow, hypereutrophic lakes. The panel's objective shall be to develop a multi-year study/monitoring plan for UKL that would further refine knowledge regarding lake management to reduce the frequency and/or magnitude of water quality-related fish kills. Based on recommendations from the panel, agencies, and Klamath Tribes, a draft multi-year monitoring plan shall be prepared by August 1, 2001.

Annual progress reports shall be prepared by Reclamation that synthesize monitoring data and make recommendations on ways to improve management of UKL so as to avoid catastrophic fish kills. The reports shall be distributed by January 1 of each year to the Service, Klamath Tribes, USGS and other Federal and State agencies [e.g., BIA, NMFS, ODEQ, ODFW, CDFG, and the North Coast Water Quality Control Board (NCWQCB)] for review and comment. The annual reports shall also be sent to the scientific panel for their comments. The comments will be used to revise the monitoring studies, if needed. Final reports shall be prepared as soon as projects are completed. Reclamation shall use the comments to revise the monitoring studies, if needed.

Reclamation shall seek funding for these monitoring and reporting requirements on an annual basis. The studies and reporting shall continue until water quality in UKL has improved to a point where it no longer is a significant threat to the survival and recovery of the suckers. These studies are necessary to provide better information on factors that cause lethal water quality in UKL in summer and below ice cover in winter. Adverse water quality is a major threat to the continued existence of the suckers. This information will avoid jeopardy by providing information that is crucial for better management of UKL to prevent water quality-related sucker die-offs.

4. *Entrainment Reduction and Fish Passage at A-Canal and Link River Dam and Monitoring and Restoration of Sucker Habitats from Keno to Link River*

A. Reclamation shall reduce sucker entrainment at A-Canal using criteria developed by the Service and ODFW at a June 29, 2000, meeting (Appendix 1). A-Canal screening shall be completed by July 22, 2002, as previously required under the July 22, 1992, BO, as amended on April 2, 1998. A draft plan and implementation schedule have already been presented to the Service and ODFW.

B. Reclamation or its designee shall reduce sucker entrainment at Link River Dam using screening or some comparable means of entrainment reduction by January 1, 2004. Unless consultation is reinitiated on the 1996 BO, a draft entrainment reduction plan and implementation schedule shall be presented to the Service and ODFW for approval by July 1, 2001.

   In the interim, operational measures shall be implemented at the Link River Dam by Reclamation or its designee to reduce entrainment until screening is completed. PacifiCorp may be Reclamation's designee with respect to these requirements by virtue of the interrelated nature of its operations at Link River Dam. Because most of the entrainment appears to occur during a few months, primarily August and September, and is concentrated at night, entrainment shall be reduced by not diverting water through the west side hydrofacilities during August and September, and water diversions shall be reduced to the greatest extent possible at east side hydrofacilities (not more than 200 cfs) at night (dusk to dawn during periods when entrainment is likely to be most significant (>100 age 0 and older suckers/day). Incidental take monitoring shall be performed annually from July through October to determine when hydropower diversions need to be temporarily suspended or reduced.

C. By January 1, 2004, Reclamation or its designee shall provide adequate passage at Link River Dam for mature LRS and SNS. A draft of the Link River fish passage plan shall be provided to the Service by July 1, 2001, for review and comment. Passage facilities shall be adequate to pass LRS and SNS of all spawning sizes, approximately 25-30 cm FL and above. Reclamation or its designee shall conduct a study in the Link River to determine what instream flows will be necessary to allow passage and if there are other passage barriers in the Link River. In support of the plan, Reclamation or its designee shall monitor suckers in the lower Link River for a minimum of two years (with a provision for extending the study if the two-year data set is inadequate) beginning in 2002, to determine the timing of sucker movements in relationship to season and flows, sizes and species composition of suckers in the river, and the ability of

suckers to pass obstructions in the river below Link River Dam at different flows. Radio-tracking of adult suckers in the Keno-Link River reach is recommended as a means to determine when adult suckers migrate, and to provide information on habitat use in this reach, as described below.

Available entrainment data indicate that tens of thousands of juvenile suckers will annually be by-passed into the reach extending from lower Link River to Keno Dam, when necessary screening is in place. It is critical to determine if these fish have adequate habitat to ensure their survival. Therefore, Reclamation shall plan and implement a study to examine habitat requirements for suckers in the Link River, Lake Ewauna, and the Keno Reservoir. The study shall focus on what habitats are available to suckers and monitor sucker survival in these areas. If insufficient/inadequate habitat are available, Reclamation shall determine what restoration actions are needed and begin taking corrective actions after coordination with ODFW, ODEQ, Klamath Tribes, and the Service. The study plan shall be provided to the State resource agencies, Tribes, and the Service by September 1, 2001, for review and comment. The study and any necessary restoration shall continue until goals are achieved, as determined by the Service. Annual progress reports shall be provided to the Service, State resource agencies, and Klamath Tribes by January 1.

These actions are necessary to avoid jeopardy and adverse modification of proposed critical habitat for the following reasons. This biological opinion identifies entrainment by the Project as a major threat to suckers in UKL, amounting to the take of millions of suckers annually. Entrainment reduction is needed to prevent suckers from being harmed or killed in Project irrigation canals or in the Link River hydroproject diversions. Passage at Link River is needed to allow suckers, by-passed downstream by the Project, the ability to migrate back into UKL and upstream tributaries where they can complete their life cycle and spawn. There is no known spawning habitat between Link River and Keno Dam, nor is it known that larval habitat is present in this reach. Without adequate passage long-term survival and recovery of suckers in UKL is not likely to occur. Habitat studies are necessary to provide better information on habitat quality in the reach between Link River Dam and Keno Dam. Information obtained in the studies will be used to manage suckers in this reach and to direct habitat restoration and improvement actions. Implementation of these actions is likely to improve survival of suckers and ensure that downstream suckers spawn, which will provide for long-term population viability.

5. *Management of UKL Water Quality Refuge Areas and Emergent Vegetation Habitats*

A. Reclamation shall prepare a draft study plan for Service review and comment by August 1, 2001. The plan shall better determine the role of "water quality refuge" areas for adult sucker survival. The role of water quality refuge areas for suckers in UKL needs to be better understood because it has important ramifications for adult sucker survival. The plan shall build on existing radio-telemetry and water quality data and make necessary recommendations for additional studies. As soon as the plan is approved, Reclamation shall undertake the study and have a draft report with management recommendations prepared for the Service review and approval by January 1, 2003, and shall begin implementation once the plan is approved.

Annual progress reports are due each January 1 until completion.

These actions are necessary to avoid jeopardy and adverse modification of proposed critical habitat for the following reasons. In this biological opinion, the Service identifies water quality refuge habitats in UKL as essential for the long-term survival and recovery of LRS and SNS. Lake management is needed to ensure adequate water depths in these refuge areas to allow suckers to survive lethal water quality conditions. Adult survival is essential for the continued existence of the suckers. These studies are needed to further refine knowledge regarding management of water quality refuge areas so that the Project can be implemented in a manner that is compatible with the conservation needs of the suckers and their proposed critical habitat.

B. Reclamation shall draft a plan, by a mutually agreeable date, for Service, ODFW, and Klamath Tribes' review, to determine the role of emergent vegetation in larval/juvenile survival. Habitat needs for larval and juvenile suckers in UKL, including lower Williamson River, are not adequately known. This has direct bearing on water quality management because an elevation of 4140.0 ft represents a threshold where, at lower levels, emergent vegetation becomes unavailable to larvae and juveniles in UKL. The plan shall also address emergent wetland restoration needs. Reclamation shall provide the Service, ODFW, and Klamath Tribes with a draft final report by January 1, 2003.

6. *Maintain Minimum Lake Levels in Clear Lake, Gerber Reservoir, and the Tule Lake Sump*

A. *Clear Lake*. Reclamation shall not divert water from Clear Lake for irrigation in any year if surface elevations are anticipated to go below 4521 ft on September 30. This surface elevation is necessary to ensure that during severe droughts there is sufficient end-of-year carry over of water and to ensure sufficient water depths in winter to adequately provide for sucker survival and reproduction and to maintain the primary constituent elements of their proposed critical habitat.

Clear Lake is very shallow and this minimum surface elevation will protect the suckers by: increasing water depth to improve water quality, especially DO during summer months when DO levels and respiration rates of suckers are highest; reduce risk of disease, which is increased by crowding; reduce predation and parasitism; and reduce risk of low DO under ice-cover conditions in winter.

Clear Lake is very prone to drought conditions because of low precipitation, seepage, and evaporation. The most extended drought occurred in the 1922-1937 period, when only one year of above-average inflow occurred in 15 years. In the drought of 1987-1992, inflow was above average in only one of six years. Estimated inflows were only 51,310 acre-ft during the 1990-1991 water year and 23,350 acre-ft in the 1991-1992 water year. Up to 1993, the surface water elevation in Clear Lake at the end of October had steadily declined from 4,531.8 ft in 1989 to 4,526.8 ft in 1990, 4,522.5 ft in 1991, and 4,519.2 ft in October 1992 as a result of a drought and irrigation water deliveries. Clear Lake reached a minimum elevation of 4,519.2 ft,

representing 28,380 acre-ft in lake volume, in October 1992, the lowest elevation for this reservoir since 1935 and only 5% of the reservoir's total capacity. The east lobe of Clear Lake was completely dry except for a small pool of water near the dam. Surface elevations lower than 4524 ft in the months of February and March reduce sucker access to Willow Creek for spawning. In 1992, low lake levels in Clear Lake prevented suckers from migrating upstream in Willow Creek to spawn.

A primary concern for fish populations in a high elevation, shallow lake such as Clear Lake is the threat of low DO under an ice cover. In October 1992, the water surface elevation was 4519.2 ft before the onset of a hard winter, and no fish kills were observed. On that basis, the Service is assuming that 4519.0 ft is the minimum surface elevation (the "hard-floor") at which the sucker populations can survive through the winter. However, such low water levels create poor water quality conditions, particularly during cold winters when the ice cover is extensive, such as 1993. As a result, the Clear Lake populations of both sucker species were in poor condition in the spring of 1993 (Service 1994b).

B. *Gerber Reservoir*. Reclamation shall not divert water from Gerber Reservoir for irrigation in any year if surface elevations are anticipated to go below 4802 ft on September 30. This elevation is necessary to ensure that during severe droughts there will be sufficient end-of-year carry over of water, and to help ensure adequate DO levels are maintained in summer that adequately provide for sucker survival and reproduction, and maintenance of the primary constituent elements of their proposed critical habitat. Below an elevation of 4800 ft, Gerber Reservoir is a relatively deep 500-acre pool, which in the summer months is stratified and prone to be hypoxic. Suckers confined to this pool in summer are at risk because of low DO levels. In winter, there is less of a threat because the pool will likely be oxygenated prior to freeze-up.

In October 1992, following a 6-year drought, Gerber Reservoir reached a minimum elevation of 4796.4 ft, which is <1% of its maximum capacity. Aeration was used to maintain water quality during the summer. Reclamation biologists found that SNS in the reservoir at that time showed signs of stress including low body weight, poor gonadal development, and reduced juvenile growth rates (Buettner, USBR, pers. comm.). SNS captured in 1992 and spring 1993 were very thin compared to SNS from Clear Lake, Tule Lake Sump and UKL. Extremely low water levels, high turbidity, and low DO concentrations probably contributed to their poor condition.

C. *Tule Lake Sump 1 A*. Reclamation shall maintain a minimum surface elevation of 4034.6 ft in Sump 1-A from April l to September 30 of each year to provide suckers spawning access, dispersal of larvae, and rearing habitat. A minimum surface elevation of 4034.0 ft must be maintained from October l to March 31 of each year to ensure adequate depths to protect the suckers from predation and freezing.

Tule Lake Sumps are extremely shallow, averaging only a few feet deep. Sedimentation has removed approximately 90 percent of the water depth in emergent wetlands in these sumps and at this rate sucker habitat will disappear in a few years if nothing is done to stop sedimentation.

Radio-tracking data show that suckers use very little of the available habitat, probably as a result of low lake levels, and perhaps adverse water quality. Adequate depth is needed to ensure adult sucker habitat is maintained. A plan shall be developed and implemented, as discussed below, to reduce sedimentation, increase water depths, and allow for some variation in water levels that will promote the development of emergent wetlands.

Finding that the RPA is Reasonable and Prudent

Implementation of the RPA will adequately address the following conservation needs of the suckers and their proposed critical habitat: loss of larval habitat owing to low reservoir levels; take of juvenile suckers by entrainment; lack of adequate fish passage preventing suckers from reaching spawning habitat; water level management contributing to adverse water quality that leads to fish kills; sedimentation and poor water quality; access to water quality refuge areas (needed to protect adult suckers from adverse water quality conditions); and winter kill of suckers from low lake levels and ice cover conditions preventing reaeration to replace DO consumed by the sediment. Implementation of the RPA allows the Project to provide water for irrigation and Refuge use in most years and to provide to listed species in low water years.

Actions identified under the RPA such as managing lake levels, providing screening and passage, collecting water quality data and preparing reports, and planning to reduce water demand are actions within Reclamation's authority and jurisdiction.

Many of the actions identified in the RPA have been identified in previous jeopardy BOs for the Klamath Project as part of the RPA, but were not implemented. Costs of these actions, when amoritized over the long life of the Project, do not reach a level that is unreasonable. Under the authority of the Klamath Basin Water Supply Enhancement Act of 2000 (P.L. 106-498), Reclamation can undertake studies to reduce Project water demand and augment supply. Screening and fish passage are economically and technically feasible since they have been widely implemented by other Federal water development projects in the West, including most other Reclamation projects.

These Reasonable and Prudent Alternatives apply to calendar year 2001 operations and beyond. Pursuant to Reclamation's, request to limit the duration of this BO to one year, Reclamation's compliance with section 7(a)(2) provided herein will expire on April 2, 2002, unless Reclamation requests formal adoption of this BO for continued operation of the Project.

Because this biological opinion has found jeopardy, Reclamation is required to notify the Service of its final decision on the implementation of the reasonable and prudent alternative.

7.0 INCIDENTAL TAKE

This incidental take statement applies to incidental take of Lost River suckers and/or shortnose suckers resulting from the operation of the Project. It replaces the incidental take statements for all previous BOs addressing Reclamation's operation of the Klamath Project.

Sections 4(d) and 9 of the Act, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harassment is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or the applicant. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by Reclamation so they become binding conditions of project authorization for the exemption under 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity that is covered by this incidental take statement. If Reclamation (1) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement 50 CFR §402.14(i)(3).

The Service developed this incidental take statement based on the premise that the reasonable and prudent alternative will be implemented. In operating the Project as specified, the Service anticipates that LRS and/or SNS could be taken in the form of harassment, harm, or mortality.

Quantification of Incidental Take

The Service anticipates that take will occur in the form of harassment, harm, or mortality of LRS and/or SNS adults, juveniles, larvae, and eggs as a result of operating the Project in accordance with this BO. We anticipate that take will likely occur as a result of the following actions related to Project operations:

(a) Entrainment (resulting in harassment and/or mortality) from Clear Lake and Gerber Reservoir into the Lost River and any associated water delivery systems.

(b) Entrainment from Upper Klamath Lake through the A-canal and into any of the associated water delivery systems.

(c) Entrainment from Tule Lake via pumps or diversions into associated water delivery systems.

(d) Negative effects of poor water quality, chemical vegetation control, entrainment in pumps, increased predation, and desiccation (resulting in harassment and/or mortality) of suckers trapped in the water delivery systems including canals, drains, fields, head-

gates and turnouts, including Straits Drain.

(e) Entrapment (resulting in harassment and/or mortality) of suckers in the outlet structures of Gerber or Clear Lake Reservoirs when the water flow is reduced or stopped.

(f) Negative effects on suckers inhabiting the Project lakes and reservoirs when water quality or quantity is reduced to stressful/lethal levels (resulting in harassment and/or mortality).

(g) Entrainment at the Link River Dam hydrodiversions and blockage of passage at the Link River Dam (resulting in harassment and/or mortality).

(h) Entrainment at C-Drop harvest facility.

(i) Loss of habitat in Project reservoirs owing to water diversions (resulting in harm related to habitat loss).

Some quantification of incidental take has been described as a result of requirements in previous BOs. The results of that effort are briefly summarized below and are described in greater detail above in section 4.0 "Effects of the Action."

A-Canal Entrainment

A-canal larval entrainment in1990 was estimated at approximately 400,000 individuals. In 1991, it was estimated that 800,000 sucker larvae were entrained into the A-Canal (Markle and Simon 1993). The 1996 and 1997 entrainment estimate for larval and early juvenile suckers was 3,000,000 (Gutermuth et al. 1997) and 1,700,000 (Gutermuth et al. 1998b), respectively. The total 1997 A-Canal entrainment index for juvenile and adult suckers was estimated at 47,000 suckers in 1997, and in1998 the entrainment index was 250,000 suckers (Gutermuth et al. 2000a). These values are best viewed as gross estimates of actual take. Given field conditions, these data are probably as good as can be expected. Because Klamath largescale suckers comprise some of the suckers and some suckers are salvaged, it might be argued that the entrainment estimates for LRS and SNS may be smaller than the totals provided above. However, owing to the short duration of the studies and low sampling efficiency of nets, and other factors, these estimates likely do not represent the maximum number of suckers entrained.

Link River Dam Diversions Entrainment

Fish entrainment studies were conducted at the two hydropower diversions on Link River Dam in 1997, 1998, and 1999 (Gutermuth et al. 1999, 2000b). An average of about 50,000 suckers per year, including Klamath largescale suckers, were entrained in the diversions. About 74% of these were <7.5 cm FL, 25% 7.5 to 15 cm FL, and 1% >15 cm FL. The East- and Westside powerhouses utilize Francis-type turbines. According to Reclamation's entrainment mortality analysis, based on Eicher Associates (1987), between 10 and 26 percent of entrained fish at

Eastside and 20 to 26 percent of entrained fish at Westside perish. Mortality is related to size, with larger fish generally suffering higher rates of turbine mortality. Entrainment injury rates and delayed mortality are unknown, and assumed significant. Delayed mortality is a concern for most fish entrained at PacifiCorp's facility and passing downstream due to poor downstream water quality and habitat conditions in Link River and Lake Ewauna.

Salvage Operations

Reclamation has conducted salvage operations in Klamath Project canals receiving water from UKL yearly since 1991. Between 1996 and 1999, the numbers of suckers salvaged were 11,000 (1996), 2,400 (1997), 2,700 (1998), and 27,000 (1999) (USBR 2000b). Age 0 fish dominated the 1996, 1998 and 1999 salvage operations and age 1+ were predominant in 1997. From 6 to 354 suckers have been salvaged annually below Clear Lake Dam between 1991 and 1999. Observed mortalities during salvage operations are low (Peck 2000).

Summary

Known take of suckers as a result of Project operation amounts to approximately 1-4 million suckers annually, mostly larvae and juveniles. This estimate is best viewed as preliminary owing to temporal limitations, sampling biases, species identification difficulties, and other factors that provide uncertainty. Furthermore, these data are primarily for entrainment losses and do not quantify the other potential sources of mortality listed above. Therefore, we assume that total annual take of endangered suckers is about 2 to 6 million LRS and SNS, when all other sources of Project-related take are added. This level of take is significant, especially since it consists primarily of age 0 suckers from populations in UKL, and this is approximately the level of annual production of age 0 suckers in UKL. However, these losses are likely to be directly correlated with annual sucker production and only be at the highest level during years when reproduction and larval survival is highest.

In order for the Service to provide an RPA, the Service must have sufficient reason to conclude that any associated incidental take would not lead to jeopardy. Any associated RPMs would further reduce or eliminate such incidental take. In five previous opinions the Service has determined that the operation of the Klamath Project would likely jeopardize the continued existence of the LRS and SNS. In these opinions, the Service concluded that if the RPAs were implemented, jeopardy could be avoided. However, the RPAs have not been fully implemented and evidence now indicates that the two endangered sucker species are more imperilled than when previous opinions were issued.
The Service anticipates that up to 6 million total individuals of Lost River and shortnose suckers may be taken annually by Project operations. Approximately 75% of these would be age 0 suckers. Actions addressed by this incidental take statement, and the corresponding levels of take, comprise:

1) entrainment from Clear Lake and Gerber Reservoir into the Lost River and any associated water delivery systems (up to 0.1 million suckers annually);

2) entrainment from UKL through the A-Canal and Link River Dam hydropower diversions and into any of the associated water delivery systems (up to 4 million suckers annually);

(3) entrainment from Tule Lake via pumps or diversions into associated water delivery systems (up to 0.01 million suckers annually);

4) negative effects of poor water quality, chemical vegetation control, entrainment in pumps, increased predation, and desiccation of suckers trapped in the water delivery systems including canals, drains, fields, head-gates, turnouts and pumps (up to 0.01 million suckers annually);

5) entrapment of suckers in the outlet structures of Gerber or Clear Lake reservoirs when the water flow is stopped (100 suckers annually);

6) negative effects on suckers inhabiting the Project lakes and reservoirs when water quality or quantity is reduced to stressful levels (1 million suckers annually);

7) negative effects of annual salvage operations in Project canals (30,000 suckers annually);

8) sedimentation of Tule Lake Sump 1A (1,000 suckers);

9) all incidental take at Link River Dam hydrodiversions and the C-drop harvest facility (0.1 million suckers annually) and;

10) all incidental take in the three Project reservoirs that result from habitat loss resulting from lower water levels caused by water diversions; and

The BA does not address, nor does the Service have any information on, the level of incidental take caused by the Straits Drain.

The Service establishes the following reasonable and prudent measures to minimize anticipated incidental take of listed suckers. The Service concludes these measures are needed because Project operations are directly or indirectly resulting in substantial incidental take of suckers by: entrainment; passage blockage; habitat loss/degradation, including adversely impacting water quality and through dessication, blockage of passage, increasing frequency of disease, parasites, and predators.

Effect of the Take

This level of take (6 million larval, juvenile and adult LRS and SNS annually) is not anticipated to jeopardize the continued existence of LRS and SNS because: (1) this is the maximum potential take that would ever occur and it should not occur at this level every year; (2) take will mostly be of larvae which would show high levels of natural mortality owing to starvation and predation; (3) some take will be in the form of harm and will not necessarily lead to mortality; (4) some take will occur multiple times as suckers are harmed by Project operations that seasonally degrade habitat and water quality; and (5) salvage of suckers in Project canals can reduce the adverse effects of

take, other than direct mortality, by returning suckers to safe areas. However, in making this statement, we do anticipate significant adverse effects of this take to sucker populations in terms of numbers, reproduction, and distribution, but conclude that timely and full implementation of the RPA elements can reduce these adverse effects to a level that will avoid jeopardy.

7.1 Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of LRS and SNS:

1. Minimize entrainment losses of suckers by conducting salvage operations in the canal systems that emanate from UKL, Clear Lake, Tule Lake, and Gerber Reservoir after these canals have been drawn down.

2. Minimize all types of take associated with operation of the Klamath Project related to actions permitted or otherwise authorized by Reclamation.

3. Provide minimum instream flows downstream from Clear Lake and Gerber Reservoir to minimize incidental take associated with end-of-season dewatering.

4. Monitor water quality in all Project lakes and reservoirs, and other features such as canals and drains where water quality is likely to adversely affect endangered suckers and provide the Service with monthly summaries and analyses, and prepare annual reports that recommend solutions. Take actions to minimize incidental take associated with identified problems.

5. Take actions at Agency Lake Ranch to minimize entrainment of suckers and adverse effects of poor water quality.

6. Minimize incidental take in the Lost River.

7. Improve water quality in lower Link River and provide adequate minimum flows in Link River.

In order to be exempt from the prohibitions of section 9 of the Act, compliance with the following terms and conditions, which implement the reasonable and prudent measures described above, is required. These terms and conditions are non-discretionary.

7.2 Terms and Conditions

The following term and condition is provided to implement RPM #1:

1a. Reclamation shall continue to conduct annual salvage of suckers stranded in the canal systems and below outlet structures of dams. Salvage plans have been developed annually since 1991. A new plan is not necessary unless the 2001 plan is found to be inadequate. Annual reports describing salvage operations are to be sent to the Service, CDFG, ODFW, and

Klamath Tribes by January 1 each year.

The following term and condition is provided to implement RPM #2:

2a. Reclamation, in coordination with the Service, the Klamath Tribes, appropriate state agencies, USGS, state universities, and/or Reclamation's designees, shall provide the Service with a draft incidental-take minimization plan for review and comment. The plan shall address all facilities where endangered suckers may be taken where operations are permitted or otherwise authorized by Reclamation, such as operations by irrigation districts, and private uses of Project water, canals, and drains. Because nearly the entire Lost River system from Clear Lake and Gerber dams to the Tule Lake sumps have been severely altered, directly or indirectly, as a result of the Project, the plan must address measures throughout that system that will reduce take, including sedimentation of Sump 1A. The objective of this plan will be to minimize incidental take as much as is possible with a focus on all forms of incidental take including but not limited to: entrainment, loss of passage, and habitat loss and degradation, such as adverse water quality, dewatering of lake, river, and streams, loss of cover, sedimentation, and other forms of loss and degradation.

The plan will describe or provide: (1) an implementation schedule of take determination monitoring; (2) a list of all Project features, including private pumps, canals and drains that are interrelated or interdependent to the Project, as described above, where take is occurring, describing the extent and mechanism of take, and ranked according to level of take; (3) a description of take reduction measures and an implementation schedule of commencement and completion of take reduction measures; and (4) a monitoring plan to measure take-reduction effectiveness. Annual progress reports shall be sent to the Service, ODFW, CDFG, and Klamath Tribes on 1 January of each year, until implementation is successfully completed.

The following term and condition is provided to implement RPM #3:

3a. Reclamation shall develop and implement a plan (with coordination of affected irrigation districts) to provide annual minimum instream flows below Clear Lake and Gerber Reservoir dams following termination of irrigation releases, if water levels in the reservoirs are above minimums required by this BO, or otherwise deemed necessary to protect suckers by Reclamation and the Service. Once the plan is developed and approved by the Service, minimum flows will be released at the end of the irrigation season and water quality and habitat monitoring will be conducted to determine if flows are adequate to protect suckers in downstream reaches of Miller Creek and Lost River.

The following term and condition is provided to implement RPM #4:

4a. Reclamation shall monitor water quality in all Project lakes and reservoirs, and other features such as canals and drains, as well as water bodies affected by Project operations where water quality is likely to adversely affect endangered suckers. This includes Clear Lake, Gerber Reservoir, the entire Lost River and Tule Lake sumps, and UKL and Link River to Keno Dam. Reclamation, with available assistance of the Klamath Tribes, appropriate state

agencies, and water quality experts from USGS, state universities, and one or more water quality experts designated by Reclamation representing its contractors, licensees, or permittees, shall develop a draft water-quality monitoring and implementation plan to be presented to the Service, state resource agencies, and interested Indian tribes for review and approval by a mutually agreeable date.

Reclamation shall monitor Project water quality and develop monthly water-quality summaries and annual reports. The report will summarize and analyze water quality data and will provide detailed analyses relating to causes and effects. A monthly report shall be provided to the Service, CDFG, ODFW, ODEQ, NCWQB, and interested Indian Tribes on the first day following each month where water quality is a concern, but must include the months of June through October. Annual reports shall be delivered to the Service, CDFG, ODFW, ODEQ, NCWQB, and interested Indian Tribes, summarizing monthly reports with in-depth analyses of data, with emphasis on how water quality affects upon listed species and habitats, and recommendations for corrective actions to be implemented by Reclamation. Annual reports will also indicate which water-quality improvements have been implemented that year along with the status of those that have not been completed.

The following term and condition is provided to implement RPM #5:

5a. Reclamation shall develop and subsequently implement, upon Service approval, a long-term method to reduce entrainment at the Agency Lake Ranch diversion by January 1, 2002.

5b. Reclamation shall implement the September 7, 1999, salvage plan during periods of pumping at Agency Lake Ranch.

5c. Reclamation shall implement the existing, Service-approved water quality monitoring plan in the Ranch impoundment and at the point of discharge in Agency Lake during periods of pumping. The objective of the plan will be to avoid pumping water into Agency Lake that might adversely affect listed suckers. No water will be released from Agency Lake if it could lead to incidental take of suckers or degrade water quality in UKL to a point exceeding ODEQ-established criteria.

5d. Reclamation shall provide the Service with an annual fish salvage and fish and water quality monitoring report. The report shall analyze monitoring and salvage data and provide any recommendations that will minimize incidental take.

5e. Reclamation shall develop a comprehensive management plan for Agency Lake Ranch, specifically addressing how incidental take of listed species (suckers and bald eagles) will be minimized which shall be provided to the Service, ODEQ, ODFW, and Klamath Tribes.

The following terms and conditions are provided to implement RPM #6:

6a. Reclamation shall prepare a report on sucker habitat use in the Lost River system and document threats to suckers. A preliminary report using existing data will identify what

additional data are needed and shall be presented to the Service for review and comment. The report should include recommendations for: better management of Reclamation's Lost River dams to reduce take; improving habitat in the channelized reach in Langell Valley; improving spawning habitat in Big and Bonanza springs; reducing rapid changes in river stage owing to an imbalance between irrigation deliveries and withdrawals; and reducing sediment and nutrient loading. Reclamation, in consultation with the Service, shall determine if, based on the preliminary report, additional data must be collected to prepare a final report.

The following terms and conditions are provided to implement RPM #7:

7a. Reclamation shall take actions under its authority to ensure that water quality in lower Link River and adjacent Lake Ewauna is adequate to protect suckers by providing minimum flows of at least 250 cfs at Link River Dam during the summer when water quality is adverse. Reclamation shall determine how DO changes with flows from Link River Dam by continuously monitoring DO and levels of flow during June through October 2001. The results of those studies will be used to develop minimum flow schedules. Reclamation will provide the Service with a report on the water quality/flow monitoring and make recommendations on necessary minimum flows based on an analysis of the data. Reclamation shall maintain minimum flows for out years based on recommendations in the report and input from the Service, ODEQ, ODFW, and the Klamath Tribes.

This Incidental Take Statement applies to calendar year 2001 Project operations and beyond. Pursuant to Reclamation's, request to limit the duration of this BO to one year, the section 9 exemptions provided herein will expire on April 2, 2002, unless Reclamation requests formal adoption of this BO for continued operation of the Project.

7.2.1 Monitoring Requirements Under the Terms and Conditions

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 species. 50 CFR, 402.14(i)(3).

Since there is currently no on-going, Project-wide incidental take monitoring of listed suckers, Reclamation shall develop an incidental take monitoring/reporting plan. Implementation of this plan will focus on quantifying as much of the incidental take as is feasible. The Service recognizes that incidental take of larvae is difficult to monitor. Also, it may not be feasible to monitor all project activities because of the numerous Project facilities that result in incidental take. The Service will determine what is reasonable, based in part on Reclamation's analysis of what incidental take can be monitored.

Because monitoring will rely on estimates of incidental take developed by appropriate sampling, the plan should be reviewed by an expert in biostatistics, to ensure the estimates are as accurate as possible. The Service recommends that existing monitoring reports be reviewed by Reclamation to determine how best to proceed. The sampling and statistical analyses must be adequate for Reclamation and the Service to determine if/when incidental take levels are being

approached/have been exceeded.

Reclamation shall provide the Service, for review and comment, with a draft incidental take monitoring plan to be implemented upon Service approval. Annual reports will be sent to this office and to Service law enforcement in Klamath Falls each year. If Reclamation determines that authorized incidental take is exceeded, this office and the Service's law enforcement office in Klamath Falls must be notified. Reclamation will be responsible for ensuring that its licensees, contractors, or designees do not exceed authorized incidental take levels.

7.3 Reporting Requirements

Upon locating a dead, injured, or sick endangered or threatened species specimen, initial notification must be made to the nearest Service Law Enforcement Office. In Oregon, contact the U.S. Fish and Wildlife Service, Division of Law Enforcement, 301 Post Office Bldg., Klamath Falls, Oregon 97601 (phone: 541/883-6900). In California, contact the U.S. Fish and Wildlife Service, Division of Law Enforcement, District 1, 2800 Cottage Way, Room W-2928, Sacramento, California 95825 (phone: 916/414-6660). Care should be taken in handling sick or injured specimens to ensure effective treatment and care and in handling 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 ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

The Service is to be notified within three (3) working days of the finding of any endangered or threatened species found dead or injured in the Klamath Project service area. Notification must include the date, time, and precise location of the injured animal or carcass, and any other pertinent information. In California and Oregon, the Service contact person for this information is Mr. Steven A. Lewis (541/885-8481). Any LRS or SNS found dead or injured in California shall be turned into the CDFG. The agency contact is Susan Cochrane (916/322-2493).

If, during the course of the action, the amount or extent of the incidental take limit is exceeded, the Federal agency must reinitiate consultation with the Service immediately.

8.0 CONFERENCE REPORT

Critical habitat was proposed in 1994, but has not yet been finalized. The primary constituent elements identified in the proposal are as follows: (1) water of sufficient quantity and suitable quality; (2) sufficient physical habitat, including water quality refuge areas, and habitat for spawning, feeding, rearing, and travel corridors; and (3) a sufficient biological environment, including: adequate food levels, and natural patterns of predation, parasitism, and competition.

The proposed action will adversely affect the primary constituent elements of the proposed critical habitat in Project reservoirs by: reducing water levels; adversely affecting water quality; and reduce access to water quality refuge areas, spawning, and larval and juvenile rearing habitats. Lower lake levels in Project reservoirs will likely make larval and juvenile suckers more

susceptible to fish predation by forcing them to use habitat away from the protective cover of shallow water and any associated wetlands. Lower lake levels also likely make juvenile and adult suckers more vulnerable to birds predators because of the shallow depths in some Project reservoirs, such as Clear Lake, Tule Lake sump, and UKL. A lack of passage at Klamath Project dams, blocks natural travel corridors to spawning and rearing habitats. Adverse water quality alters the natural pattern of disease and parasitism within the sucker populations, increasing their frequency and intensity.

The Service has examined the effects of the proposed action and determines that proposed critical habitat for the LRS and SNS will be modified by: (1) temporary reductions of water levels by water diversions during critical periods making seasonally habitats unsuitable; (2) longer-term reductions in water levels by sedimentation making habitat permanently unsuitable; (2) reductions of water quality sufficient to make habitats unsuitable over short and long time periods; (3) blockage of passage preventing suckers from using habitats necessary for completion of life cycle; and (4) other factors. The Service's preliminary determination is that these adverse effects will be of a sufficiently high degree and extent that they will likely lead to adverse modification of proposed critical habitat.

9.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" is defined as suggestions from the Service regarding discretionary measures to: (1) minimize or avoid adverse effects of a proposed action on listed species or critical habitat; (2) conduct studies and develop information; and (3) promote the recovery of listed species. The recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of the agency's 7(a)(1) responsibilities under the Act.

1. The Service recommends that Reclamation survey all of its properties for the presence of Applegate's milk-vetch or its suitable habitat.

2. The Service recommends that Reclamation survey for spotted frogs on its Agency Lake Ranch property and consider if it could develop suitable habitat there for this species as a conservation action.

3. The Service recommends that Reclamation investigate the feasibility of establishing a population of Lost River suckers in Gerber Reservoir with broodstock from Clear Lake. If deemed feasible, Reclamation should work with BLM, ODFW, and the Service to plan and implement this effort.

4. Water quality/quantity in UKL has gotten worse over time owing to anthropogenic changes in its watershed. The Service recommends that Reclamation evaluate the role watershed/riparian/floodplain has in providing high quality/quantity flows into UKL, and implement a long-term restoration plan to restore degraded and lost functions.

5. Emergent wetlands in UKL and in tributary streams appear to have played an important function in nutrient cycling and in producing humic substances that may retard *AFA* growth. The Service recommends that Reclamation fund additional studies on wetland functions.

6. Chiloquin Dam has a poorly functioning fish ladder. The Service recommends that Reclamation work with the Service, The Klamath Tribes, the Modoc Irrigation District, and others to secure funding to repair the ladder. If implemented, this could provide additional valuable spawning habitat for UKL suckers.

7. The Service recommends that Reclamation serve as a clearing house for water quality data from the Upper Klamath Basin, especially for those basins which directly affect water quality in Project lakes, reservoirs, rivers, canals, and drains. Reclamation is the agency with the most control of water in the upper basin. It should be proactive in efforts to share data among all interested parties. This would make data more available to anyone and would facilitate management. Currently data are scattered among numerous agencies and organizations.

8. *Water Conservation/Reduction of Project Water Consumption Plan*

   Reclamation should reduce water consumption by the Project consistent with Reclamation's legal authority and jurisdiction. Reclamation should develop a draft water conservation and Project water consumption reduction plan by a mutually agreeable date for Service review and comment. Reclamation should incorporate the approved plan into all future Project operation plans. Annual reports describing water conservation and use reduction progress shall be prepared.

9. *Planning to Improve Water Quality in the Tule Lake Sumps*

   Reclamation should work with the Service to develop a plan by a mutually agreeable date that will protect suckers in the sumps from the adverse effects of sedimentation and poor water quality. The plan is needed to increase water depths and allow varying water levels so that emergent vegetation can be reestablished. Over the last 30 years, under a management regime that allowed for only a one foot annual fluctuation in water levels, Tule Lake wetland areas have declined dramatically, including areas with bulrush. These types of habitat are essential to provide for sucker survival, reproduction, and the primary constituent elements of their proposed critical habitat.

In order to be kept informed of actions that either minimize or avoid adverse effects or that benefit listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

10. REINITIATION NOTICE

This concludes the conference for the Klamath Project. You may ask the Service to confirm the conference opinion as a biological opinion issued through formal consultation if the critical habitat

is designated. The request must be in writing. If the Service reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, the Service will confirm the conference opinion as the biological opinion on the project and no further section 7 consultation will be necessary.

Reclamation shall request reinitiation of consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect the critical habitat in a manner or to an extent not considered in this conference opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the critical habitat that was not considered in this conference opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

The Service appreciates the efforts made by Reclamation staff to assist completion of this consultation. The Service also appreciates the assistance of individuals in the following agencies/organizations who provided us with critical scientific information and/or reviewed parts of this opinion: BIA, CDFG, The Klamath Tribes, NMFS, ODFW, ODEQ, OSU, PacifiCorp, and USGS (BRD and Water Resources Div.).

If you have any questions regarding this opinion, please contact the Klamath Falls Fish and Wildlife office Project Leader at (541) 885-8481.

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Personal Communications

Buettner, M., U.S. Bureau of Reclamation, Klamath Project Office, 6600 Washburn Way, Klamath Falls, OR, 97602-9365

Dunsmoor, L., The Klamath Tribes, P 0 Box 436, Chiloquin, OR 97624

Gutermuth, Brandt. Fishery Biologist. The New Earth Company, Klamath Falls, Oregon.

Hainline, J. Wildlife Biologist. Klamath Basin National Wildlife Refuges, 4009 Hill Road, Tulelake, CA 96134

Hamilton, Andy. Fishery Biologist. Bureau of Land Management, Klamath Falls, Oregon.

Kann, J. Aquatic Ecologist. Klamath Tribes, P.O. Box 436, Chiloquin, OR 97624

Kirk, S. Water Quality Specialist, Oregon Department of Environmental Quality, Bend, OR.

Loftus, M. R2 Resource Consultants Inc., 1520 NE 95th St. Redmond, WA 98052

Maria, D., California Department of Fish and Game, P.O. Box 509, Yreka, CA 96097

Markle, D.F., Department of Fisheries & Wildlife, 104 Nash Hall, Oregon State University, Corvallis, OR 97331

Mauser, D. Wildlife Biologist, USFWS, Klamath Basin Refuge Complex, Tulelake, CA

Perkins, D. Fish Biologist, USFWS, Hadley, MA

Reid, S. Fish Biologist, USFWS, Klamath Falls Office, Klamath Falls, OR

Scoppettone, G.G., Service, National Fisheries Research Center, Reno Field Station, 4600 Kietzke Lane, Bldg. A, Suite 109, Reno, NV 89510

Shively, Rip. Fishery Biologist. Biological Resources Division, U.S. Geological Survey, Klamath Falls Duty Station, Klamath Falls, Oregon.

Shrier, Frank. Lead Scientist. PacifiCorp, Corvallis, Oregon.

Smith, R. Fish Biologist, ODFW, Klamath Falls, OR

Snyder-Conn, E. Contaminants Specialist, USFWS, Arlington, VA

Yamagiwa, M. Fish Biologist, Modoc National Forest, Alturus, CA

Appendix 1

A-Canal Screening Criteria

I. Introduction

The following site-specific screening criteria for A-canal were jointly developed by Oregon Department of Fish and Wildlife (ODFW) and the U.S. Fish and Wildlife Service (FWS) at a meeting held in the ODFW Portland Office on June 29, 2000.

II. Purpose and Need

Bureau of Reclamation, Klamath Project, funded studies show that large numbers of endangered Lost River and shortnose suckers, as well as other native fishes are annually entrained into A-canal during the irrigation season. Entrainment reduction is needed to be compliant with Endangered Species Act requirements and ODFW regulations requiring screening on diversions...

III. Screening Criteria (unless otherwise noted, these criteria shall be those of National Marine Fisheries Service used in the Pacific Northwest)

A. Screen Mesh Size:	2.3 mm wedge wire, maximum mesh size
B. Approach Velocity:	0.4 feet/second, maximum

IV. Recommended sweeping flow and bypass guidelines beyond those in the NMFS criteria.

A. Sweeping Flow:	Twice the approach velocity, minimum; recommended target 2 feet/second and accelerating towards entrance to bypass
B. Bypass:	Each should be: 2 feet wide opening; flow controlled by ramp; equipped with removable fish trap (mandatory); flows should be between 30 and 100 cfs; velocities at the entrance to each bypass should be > 2 feet/second but optimally 8 feet/second; maximum acceleration approaching bypass 0.1 to 0.2 feet/second-squared

Appendix 2

Coordination between National Marine Fisheries Service and Fish and Wildlife Service on Klamath River Flows and Upper Klamath Lake Levels for 2001

Representatives from the Service, NMFS, BIA, and the Karuk, Yurok, and Klamath Tribes met on March 28th and reached tentative agreement on management of water for the 2001 water year. There was to be additional review and finalization later. Meetings were held between the Service, NMFS, BIA, and other agencies on April 1-2, 2001. During the April meetings the same level determined during the March meeting were deemed to be appropriate. Consequently Reclamation shall adopt the following elevations and river flows in the 2001 operations plan.

A) Proposed River Flows and Lake Levels:

River Needs					**Lake Needs**		
			Draft BO			Draft BO	Proposal
April 1	Ramp Up	Fry/Smolt	1700	1850	Lake Spawning	4142.5	
2	Stable	Fry/Smolt	2100	1850	Lake Spawning	4142.5	
May 1	Stable	Fry/Smolt	2100	1850	Lake Spawning	4142.5	
2	Stable	Fry/Smolt	2100	1850	Larval Habitat	4142.5	4141.8 May 30
June 1	Ramp Down	Fry/Smolt	1800	1850	Larval Habitat & WQ	4141.5	
2	Ramp Down	Fry/WQ	1400	1850	Larval Habitat & WQ	4141.5	
July 1	Base Flows	WQ/Juv	1000	1000	Larval Habitat & WQ	4141.5	4140.0 July 15
2	Base Flows	WQ/Juv	1000	1000	Larval Habitat & WQ	4141.0	
Aug 1	Base Flows	WQ/Juv	1000	1000	WQ, Adult Refugia	4141.0	
2	Base Flows	WQ/Juv	1000	1000	WQ, Adult Refugia	4140.5	
Sept 1	Ramp Up	WQ/Spawn	1300	1000	WQ, Adult Refugia	4140.5	
2	Ramp Up	WQ/Spawn	1300	1000	WQ, Adult Refugia & Winter Kill	4140.0	4139.0 Sept 30

B) That there is to be follow-up coordination throughout the year as water forecast and availability became available. Coordination would include NMFS, FWS, BIA and Tribes.