Lost River, California
Total Maximum Daily Loads

Nitrogen and Biochemical Oxygen Demand
to address
Dissolved Oxygen and pH Impairments

PUBLIC REVIEW DRAFT: MARCH 2007

Established by date

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Acknowledgements and Contact Information.

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CHAPTER 1: INTRODUCTION

1.1 OVERVIEW OF THE TMDL PROGRAM

The purpose of the Clean Water Act's Total Maximum Daily Load (TMDL) program is to assure that water quality standards are attained and maintained in waters that are now polluted. The water quality problems addressed in this report – reduced dissolved oxygen, elevated pH, and excessive algal and macrophyte growth caused, in part, by excessive discharges of nitrogen and organic matter– are partly responsible for degradation of aquatic habitat conditions in the Lost River system.

The TMDL process involves the identification of "impaired" or polluted water bodies on the State Section 303(d) list, and the development of pollutant control plans called TMDLs for each polluted water identified on the Section 303(d) list. These TMDLs for the Lost River in California are being established under Section 303(d) of the Clean Water Act subsequent to their listing by the State of California.   Under Section 303(d), the State of California periodically identifies *"those waters within its boundaries for which the effluent limitations... are not stringent enough to implement any water quality standard applicable to such waters."* In 1992, EPA added the Klamath River basin, which includes the Lost River system, to California's Section 303(d) impaired water list due to elevated nutrients and temperature. The State of California has continued to identify the Lost River as impaired due to nutrients and temperature in subsequent biennial listing cycles. Specifically, the State listed the "Klamath River Hydrologic Unit, Lost River Hydrologic Area, Tule Lake and Mount Dome Hydrologic Sub Areas (HSA)" (see Figure 1); this area is also sometimes referred to as the "Lower Lost River." For the purposes of this document, "Lost River" refers to the water bodies in this Lower Lost River hydrologic area. California also listed Tule Lake and Lower Klamath Lake National Wildlife Refuge for pH[1].

In preparation for completing this TMDL, EPA and the State of California reviewed the record supporting the prior listings for the Lost River system. The State of California determined that available data and information do not support the continued listing of Upper Lost River (upstream from Malone Dam) for nutrients or temperature, nor of Lower Lost River (downstream of Anderson Rose Dam below the Oregon border) for temperature. Available data and information support the continued listing of the entire Lower Lost River system for nutrients, and the Tule Lake and Lower Klamath Refuges for pH. The State of California removed the Section 303(d) listings for the Upper Lost River and for Lower Lost River temperature in October 2006; therefore, no temperature TMDLs are being developed for temperature for Upper Lost River or Lower Lost River in California.

In accordance with a consent decree (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus, No. 95-4474 MHP, 11 March 1997*), the TMDLs necessary for Lost River must be completed by 2007. As the consent decree requires

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[1] Throughout the remainder of this TMDL, Tule Lake will be referred to as "Tule Lake Refuge", and Lower Klamath Lake will be referred to as "Lower Klamath Refuge".

preparation of TMDLs for all listed portions of the Lost River Hydrologic Area, these TMDLs were developed to address nutrients and pH in the Lower Lost River, Tule Lake Refuge, Lower Klamath Refuge, and Straits Drain in California. Because the State of California will not be adopting TMDLs for the Lost River system by this deadline, EPA is establishing these TMDLs. EPA worked closely with the North Coast Regional Water Quality Control Board in the development of these TMDLs.

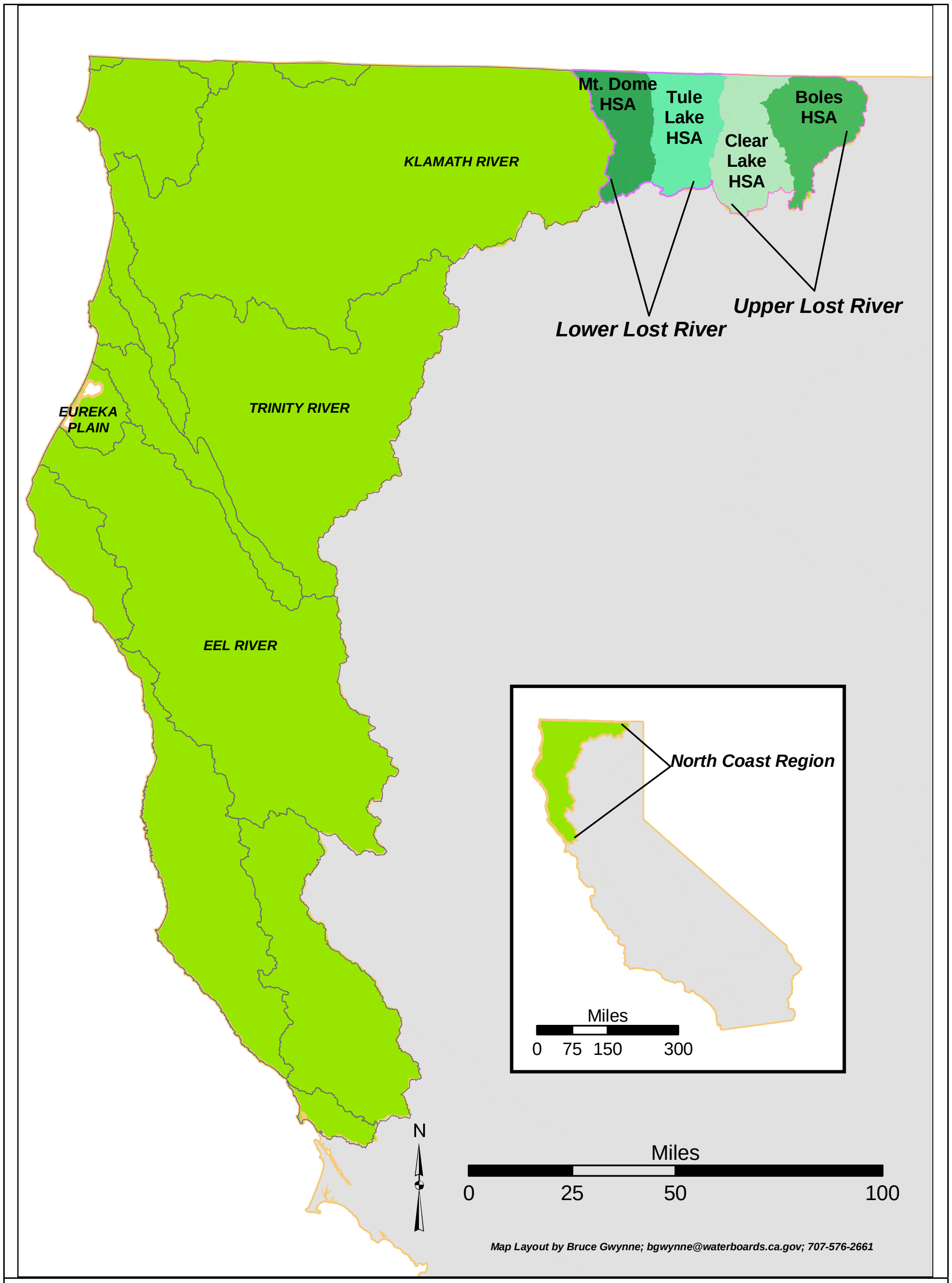

Figure 1. Location of Lost River, Klamath River Watershed, California

The State of Oregon listed several segments of the Lost River on its Section 303(d) list for dissolved oxygen, chlorophyll, pH, ammonia toxicity, and bacteria. EPA coordinated closely with Oregon Department of Environmental Quality (ODEQ) on the Lost River TMDLs for California; however, EPA is not setting TMDLs to address the Lost River Section 303(d) listings in Oregon in the current action. ODEQ is currently working with EPA and the State of California to develop TMDLs to address the mainstem of Klamath River to address nutrient, dissolved oxygen, and temperature impairments in several Klamath River segments. ODEQ plans to develop TMDLs as needed for the Lost River in Oregon as part of the broader Klamath River TMDL effort. EPA is proceeding to establish TMDLs for the Lost River in California at this time in order to meet its obligations under the consent decree.

ODEQ adopted TMDLs for Upper Klamath Lake basin in 2002 that control phosphorus loads to address dissolved oxygen, chlorophyll-a, and pH impairments in Upper Klamath Lake and also to address dissolved oxygen, pH, and temperature impairments in waters that are tributary to Upper Klamath Lake.[2] In contrast to the Lost River system which is primarily nitrogen limited, Upper Klamath Lake water quality impairments are limited principally by high phosphorus levels.

EPA is including implementation recommendations in this document to assist local stakeholders in targeting actions to address suspected causes of water quality impairment in the Lost River system. These implementation recommendations, contained in Chapter 7 of this document, are not part of the TMDLs in Chapter 6 that are being established by EPA pursuant to Clean Water Act Section 303(d) and federal regulations at 40 CFR 130.7. The implementation recommendations are strictly advisory and are not required to be implemented under federal law. We encourage the State and local stakeholders to consider these implementation recommendations to guide future water quality protection efforts in the basin.

1.2 LOST RIVER TMDL SUMMARY

The Lost River TMDLs identify the maximum amount (or load) of nitrogen (specifically, dissolved inorganic nitrogen or DIN)[3] and biochemical oxygen demand (BOD) (specifically, carbonaceous BOD or CBOD) that can be delivered to the Lost River such that the River can still meet applicable water quality standards for nutrients, dissolved oxygen, and pH. Modeling and data analysis conducted for this TMDL determined that the most significant nutrient-related impairment in the system is low dissolved oxygen levels; hence the TMDLs are designed principally to ensure attainment of California's numeric dissolved oxygen water quality standard. That analysis also found that DIN and CBOD reductions sufficient to attain the dissolved oxygen standard will also be sufficient to attain the pH standards.

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[2] See TMDLs at http://www.deq.state.or.us/wq/tmdls/docs/klamathbasin/ukldrainage/tmdlwqmp.pdf

[3] Dissolved inorganic nitrogen, or DIN, is comprised of nitrate, nitrite, and ammonia and is the form of nitrogen most bioavailable to aquatic plants and algae.

The total allowable DIN and CBOD loads are allocated among the sources of DIN and CBOD loading in the watershed. The TMDLs, when implemented, are expected to result in achieving the applicable water quality standards for nutrients, dissolved oxygen, and pH for Lost River in California. Our goal is to achieve an improving trend in water quality conditions in the Lower Lost River basin through the implementation of a mosaic of actions to reduce overall loads. We have incorporated adaptive management and monitoring programs into the implementation recommendations. In addition, EPA expects the Regional Board to incorporate these TMDLs, and implementation plans to be developed by the Regional Board, in its Basin Plan that will result in implementation of necessary pollutant controls in accordance with the requirements of federal regulations at 40 CFR 130.6. In order to assist the Regional Board in developing an implementation plan, EPA is including in this TMDL document specific implementation recommendations intended to guide implementation of pollutant controls necessary to meet the TMDL.

The Lost River originates in California at the outlet of Clear Lake, before it flows north into Oregon where it receives substantial inflow from Gerber Reservoir and the A-Canal diversion of Klamath River water. This portion of the Lost River in California is often referred to as the Upper Lost River. As the State of California removed from the Section 303(d) list all listings for Upper Lost River in California, EPA is not establishing any TMDLs for the Upper Lost River in California.

As the map in Figure 2 shows, the Lost River flows from Oregon back into California to the Tule Lake Refuge. Outflow from Tule Lake Refuge is pumped to the Lower Klamath Refuge via a branch of P-Canal. Outflow from the Lower Klamath Refuge flows into Straits Drain, which reenters Oregon just downstream from Lower Klamath Lake. The Lost River Hydrologic Area listed on the California 303(d) list and addressed in these TMDLs includes:

- Lower Lost River from the Oregon Border to Tule Lake Refuge,
- Tule Lake Refuge (including the sumps and surrounding leased lands),
- Lower Klamath Refuge, and
- Straits Drain from Lower Klamath Refuge to the Oregon Border.

The Lost River watershed traverses the states of Oregon and California, encompassing an area of approximately 2,996 square miles. The watershed includes portions of Klamath and Lake Counties in Oregon, and Modoc and Siskiyou Counties in California. Approximately 56 percent of the watershed (roughly 1,667 square miles) lies in California, while 44 percent (roughly 1,328 square miles) is located in Oregon. The Klamath irrigation project delivers water to approximately 200,000 acres comprised of 130,000 acres in Oregon and 70,000 in California. The mainstem of the Lost River is highly channelized and includes several impoundments (Harpold Dam, Wilson Diversion Dam, Anderson Rose Dam, Tule Lake Refuge, and Lower Klamath Refuge) to facilitate water storage, diversion, and agriculture return flow. It is a highly modified environmental system driven largely by irrigation operations and, as a consequence, the system exhibits tremendous biological activity.

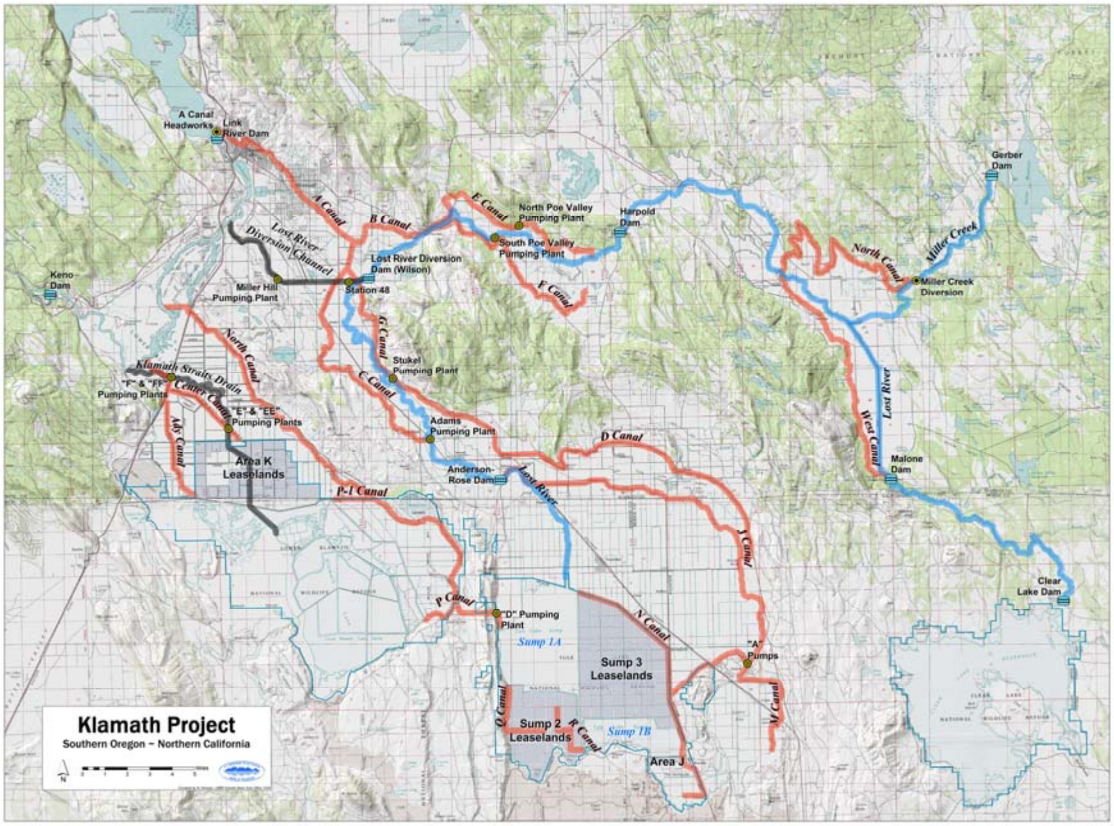

Figure 2. Map of Lost River Watershed. Source: U.S. Bureau of Reclamation.

The current hydrology bears little resemblance to the pre-development condition. Development of the irrigation projects resulted in major losses of natural riparian and wetland areas in the Lost River, as well as in the historic Tule Lake, and Lower Klamath Lake areas (see Figure 3). Lower Klamath Lake was an extensive shallow lake and wetland area that received water from the Klamath River during spring flood events. Wetlands and open water in Lower Klamath Lake historically covered 80,000-94,000 acres in spring and 30,000-40,000 acres in late summer. Riparian and wetland areas historically helped to filter pollutants from runoff to these receiving waters. After the Klamath Irrigation Project was developed by the 1920s, wetland and open water acreage in Lower Klamath Lake declined by more than 90 percent, and its natural hydraulic connection to the Klamath River was severed by construction of a dike. None of the historic lake exists today as it has been replaced with a system of managed wetland impoundments interspersed with agricultural fields. Similarly, before construction of the Klamath Irrigation Project, Tule Lake averaged about 95,000 acres in size. The Klamath Irrigation Project delivers water to approximately 200,000 acres, of which 35% are located in California. After the Irrigation Project was developed and much of Tule Lake was drained for agriculture, open water and wetland acreage declined by about 90% (FERC, 2006). The historic Tule Lake has been replaced by two interconnected sumps, and adjacent cropland.

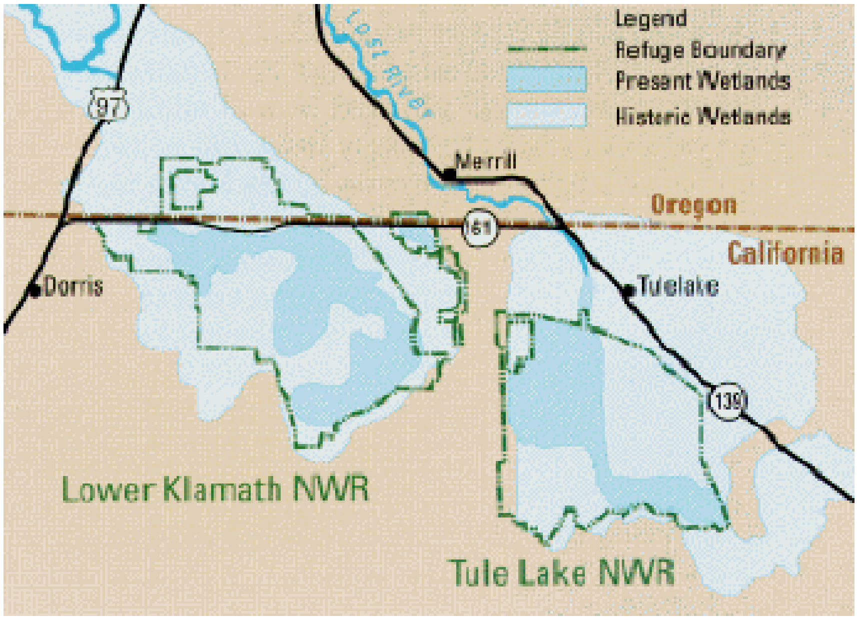

Figure 3. Historic wetlands area in Lower Lost River basin. Source: United States Fish and Wildlife Service, Klamath Basin National Wildlife Refuges.

High nutrient and organic matter loading in the Lost River system promotes the production of aquatic plants and algae (macrophytes, epiphyton, periphyton, and phytoplankton), resulting in violations of numeric water quality standards for dissolved oxygen and pH, and narrative nutrient standards. During the growing season, the growth of aquatic plants and algae appears to be limited by the available nitrogen in the Lost River. Biochemical oxygen demand (BOD), in the water column and sediment, also contributes to the dissolved oxygen limitation. High nitrogen and BOD loads come principally from water diversions into the Lost River system, agricultural return flows, and cycling of nutrients and organic matter from water body bottom sediments. When solids that contain organic matter settle to the bottom of a stream they may decompose anaerobically (with no oxygen present), or aerobically (in the presence of oxygen), depending on conditions. The oxygen consumed in aerobic decomposition of these sediments is called sediment oxygen demand (SOD) and represents a loss of dissolved oxygen for a stream. Biological processes associated with cycling of excessive nitrogen and organic material loads (and associated growth of aquatic plants) are responsible for swings in dissolved oxygen and pH levels that cause violations of applicable dissolved oxygen and pH water quality standards. The data and modeling analysis conducted to support this TMDL found that reductions in DIN and CBOD loadings of approximately 50% from the estimated baseline loads from 1999 (which would produce commensurate reductions in SOD) would be sufficient to bring about attainment of the applicable pH and dissolved oxygen water quality standards in California. Table 6 identifies the actual load allocations.

The climate of the Lost River subbasin is generally characterized by dry summers with high temperatures and wet winters with moderately low temperatures. About two-thirds of annual precipitation falls as snow between October and March. Total average snowfall at Klamath Falls, Oregon is about 41 inches. Mean yearly total precipitation measured at Klamath Falls from 1961-1990 was 13.5 inches.

The headwaters of the Lost River lie within California, upstream of Clear Lake. The portion of Lost River above or upstream of Malone Dam, located near the California border, is referred to here as Upper Lost River. The portion downstream of Malone Dam is referred to here as Lower Lost River. The Lower Lost River flows northwest downstream from Malone Dam, then turns westward and eventually southward toward California, where it reenters California below Anderson Rose Dam. The Lower Lost River then flows south into Tule Lake Refuge.[4] After being pumped from Tule Lake Refuge through P-Canal, the River flows into Lower Klamath Refuge.[5] Downstream from Lower Klamath Refuge, the Klamath Straits Drain is pumped northwest until its final discharge point to Klamath River.

The mainstem of the Lost River is highly channelized and includes several impoundments to facilitate water source and support diversion canals and return flow drains. The principal source of water inflows to the Lost River system in California is agricultural drains that collect irrigation return flows from agricultural operations in the Klamath Irrigation Project. Much of the supply water to these operations comes from water supply canals that divert water from upstream locations in the Lost River system (e.g., D, G, J, and N Canals). Flow varies seasonally. In winter, substantial amounts of Lost River flow come from reservoirs within the Lost River watershed and excess flows are diverted via the Lost River Diversion Channel to the Klamath River. In summer, most Lost River flows in California come from the Upper Klamath Lake via the Link River or from Keno Reservoir in the Klamath River system via diversion canals.

Most of the land adjacent to Lost River upstream from Lower Klamath Refuge is privately owned. Portions of Tule Lake and most of Lower Klamath Lake are currently part of the National Wildlife Refuge system and are managed by US Fish and Wildlife Service. Some refuge lands are jointly managed by Bureau of Reclamation for agricultural use.

1.3 ORGANIZATION

This report is divided into 8 chapters. Chapter 2 (Problem Statement) describes the nature of the environmental problems addressed by the TMDLs – nutrient and BOD-related effects on aquatic habitat and associated water quality standards violations. Chapter 3 (Numeric Targets) describes the water quality indicators used in the analysis that represent attainment of applicable water quality standards. Chapter 4 (Source Analysis) describes estimates of nitrogen and BOD loading within the watershed. Chapter 5 (Loading Capacity Linkage Analysis) describes the modeling and data analysis used to evaluate the effects of nitrogen and BOD loading in the Lost River

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[4] Tule Lake Refuge (including the Sumps 1-A and 1-B) are treated as one water body for purposes of the TMDL analysis and allocations.

[5] All units within the Lower Klamath Refuge are treated as one water body for purposes of the TMDL analysis and allocations.

system and determine level of pollutant reductions necessary to attain applicable water quality standards. Chapter 6 (TMDLs and Allocations) describes the TMDLs and associated allocations based on the linkage analysis. This chapter also describes how the TMDL analysis provides the requisite margin of safety and addresses seasonal variations and critical conditions. Chapter 7 ((Implementation and Monitoring Recommendations) contains recommendations to allocation holders and the State regarding implementation and monitoring of the TMDLs. Chapter 8 (Public Participation) describes public participation in the development of the TMDLs and implementation recommendations.

CHAPTER 2: PROBLEM STATEMENT

This chapter includes a description of the water quality standards and potential effects of elevated nutrients and BOD on dissolved oxygen and pH in the Lost River. In summary, aquatic habitat in the Lost River system is impaired due to low dissolved oxygen and excessive pH conditions, which, in turn, are caused by excessive nitrogen and BOD loading that causes excessive algal growth and consumption of dissolved oxygen in the water column and sediments.

2.1 WATER QUALITY STANDARDS

In accordance with the Clean Water Act, TMDLs are set at levels necessary to achieve the applicable water quality standards. Under the federal Clean Water Act, water quality standards consist of designated uses, water quality criteria to protect the uses, and an antidegradation policy. The State of California uses slightly different language (i.e., beneficial uses, water quality objectives, and a non-degradation policy). This section describes the State water quality standards applicable to the Lost River TMDLs using the State's terminology. The remainder of this document simply refers to water quality standards.

The beneficial uses and water quality objectives for the Lower Lost River (Table 1) are contained in the Water Quality Control Plan for the North Coast Region (Basin Plan), as amended (NCRWQCB, 2005).

Table 1. Beneficial Uses of the Lower Lost River Subbasin, California

Beneficial Use	*Designation*	*Beneficial Use*	*Occurring*
Rare, Threatened or Endangered Species	Existing	Coldwater Habitat	Potential
Agricultural Supply	Existing	Water Contact Recreation	Potential
Industrial Service Supply	Potential	Non-Contact Recreation	Existing
Industrial Process Supply	Potential	Commercial & Sport Fishing	Existing
Groundwater Recharge	Existing	Warm Freshwater Habitat	Existing
Freshwater Replenishment	Existing	Wildlife Habitat	Existing
Migration of Aquatic Organisms	Existing	Aquaculture	Potential
Municipal and Domestic Supply	Potential	Spawning and Reproduction	Existing

The habitat-related beneficial uses are of greatest concern in these TMDLs because of the potential adverse impact of depressed dissolved oxygen and elevated pH levels on native fish in the Klamath basin including the Shortnose sucker (*Chasmistes brevirostris*) and Lost River sucker (*Deltistes luxatus*). Both sucker species were listed as endangered under the federal Endangered Species Act in 1988, and water quality degradation resulting from algal blooms was identified as a probable major factor in their declines (Williams 1988).

The Basin Plan includes both narrative and numeric water quality objectives designed to protect that designated beneficial uses that are pertinent to these TMDLs.

Biostimulatory Substances (Nutrients) Narrative Objective (applicable to all waters)

> "Waters shall not contain biostimulatory substances (nutrients) in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses."

Numeric Objective for Dissolved Oxygen

> Lower Lost River, Tule Lake Refuge, Lower Klamath Refuge: greater than or equal to 5.0 mg/l (absolute minimum).

Numeric Objective for pH

> Tule Lake Refuge, Lower Klamath Refuge: minimum of 7.0 and not to exceed 9.0.

2.2 DISCUSSION OF WATER QUALITY STANDARDS VIOLATIONS

This section presents a discussion of observed water quality standards impairments for the entire Lower Lost River system in order to provide a more comprehensive analysis of existing conditions. Note that the dissolved oxygen standards in Oregon vary seasonally and are higher than California standards in some months and lower than California's in others.[6] Overall, from Malone Dam to the outlet at Klamath Straits Drain, the Lost River is impaired when considering dissolved oxygen and shows a general worsening of conditions in the downstream direction (Figure 4). California's dissolved oxygen standards are violated in Lost River below the Oregon Border, in Tule Lake Refuge, and in Lower Klamath Refuge. PH impairment appears to be limited to downstream of Anderson Rose Dam with consistently elevated values occurring in Tule Lake Refuge (Figure 5). Levels of ammonia (NH_3) in Klamath Straits Drain in Oregon were found to be higher than applicable Oregon water quality standards; however, no violations of California's narrative water quality standard addressing water column toxicity were observed and there is no current evidence of ammonia-caused violations in California.

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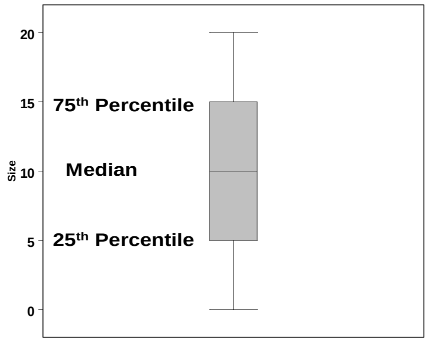
[6] More information concerning Oregon water quality standards may be found at the following website: http://www.deq.state.or.us/WQ/standards/wqstdshome.htm

In this report, box plots are used to illustrate the distribution of samples through time or among places. The percentile indicates the percentage of sample values less than the value at that point in the distribution. In example 1 (top), 75%of sample values are lower than 15 and 25% are lower than 5. By definition, the median is the 50th percentile, with 50% of values lower and 50% of values higher than the median. In the figures that follow, numbers at the bottom of each plot are sample sizes.

Box and Whisker Plot Example 1

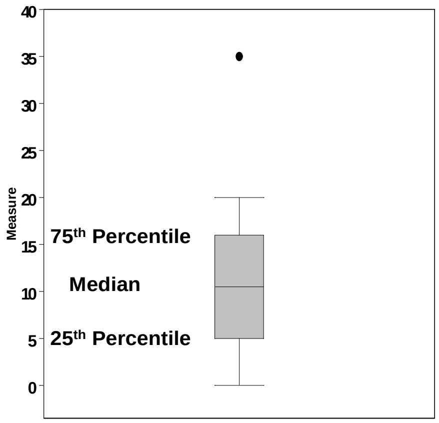


In the Box Plot at left, the numbers 0 through 20 are plotted based on their distribution as a percent of the total.

The median = 10
75th Percentile = 15
25th Percentile = 5

Ends of the "whiskers" are the extreme values in the data excluding "outliers"

Box and Whisker Plot Example 2



In the Box Plot at left, the numbers 0 through 20 are plotted based on their distribution as a percent of the total. An additional number,35, is plotted as an "outlier"

Outliers are greater than 1.5 times the range between the 25th and 75th Percentiles

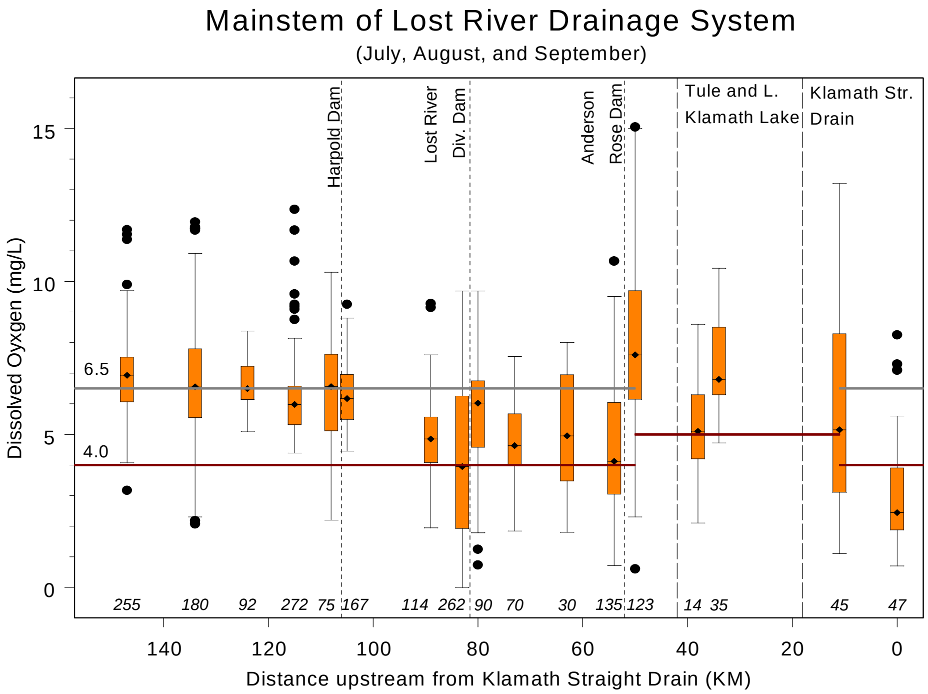


Figure 4. Longitudinal variation of the dissolved oxygen concentrations during summer months (applicable standards in Oregon and California denoted by the horizontal bars).

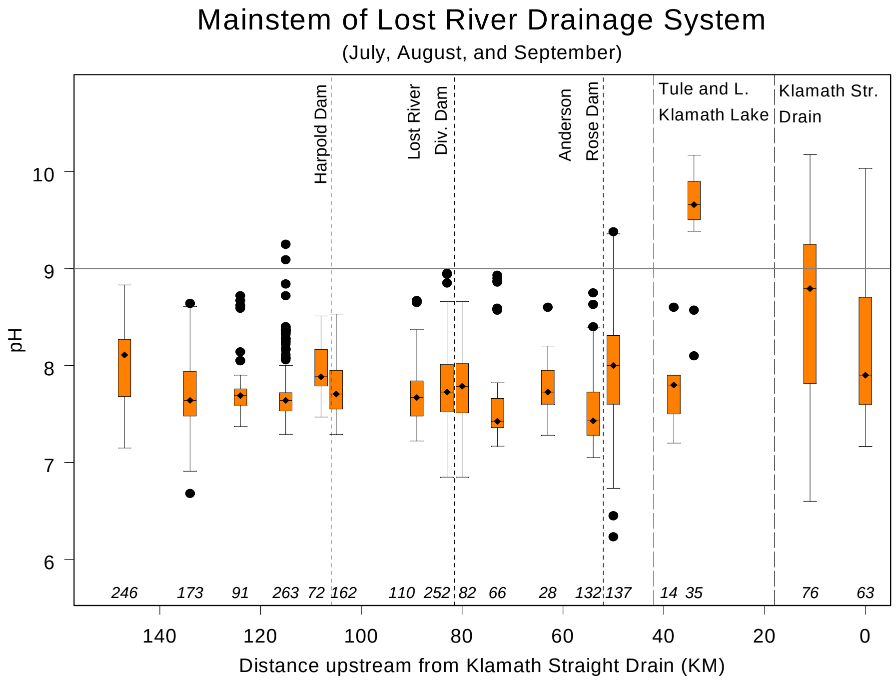


Figure 5. Longitudinal variation of the pH during the critical summer months. The applicable standard is denoted by the horizontal line.

2.3 SEASONAL VARIATIONS AND CRITICAL CONDITIONS

Critical levels of dissolved oxygen and pH occur predominantly during the summer, from June through September. Consequently, the critical period for this TMDL analysis is the 122-day period from June 1st to September 30th. As Klamath Straits Drain is one of the most impacted, regularly-sampled monitoring location, it was chosen to show the seasonal variation in dissolved oxygen levels (see Figure 6). July and August appear to be the most impaired months for dissolved oxygen but minimum values have been measured that are lower than the standards from May to November. Exceedances of the DO standard are more frequent between June and September. Exceedances above the pH standard occurred only in June. The data indicate that the critical condition for water quality standards exceedances is the period between June and September. This period holds the highest potential for excessive aquatic plant and algae growth because nutrient and BOD loads are relatively high, air and water temperatures are high, and more sunlight is available during the long daylight hours to stimulate plant and algae growth. However, as nutrients and organic material discharged during the winter and spring months may remain in the system for several months, it is important to ensure that nitrogen and BOD loads are controlled throughout the year.

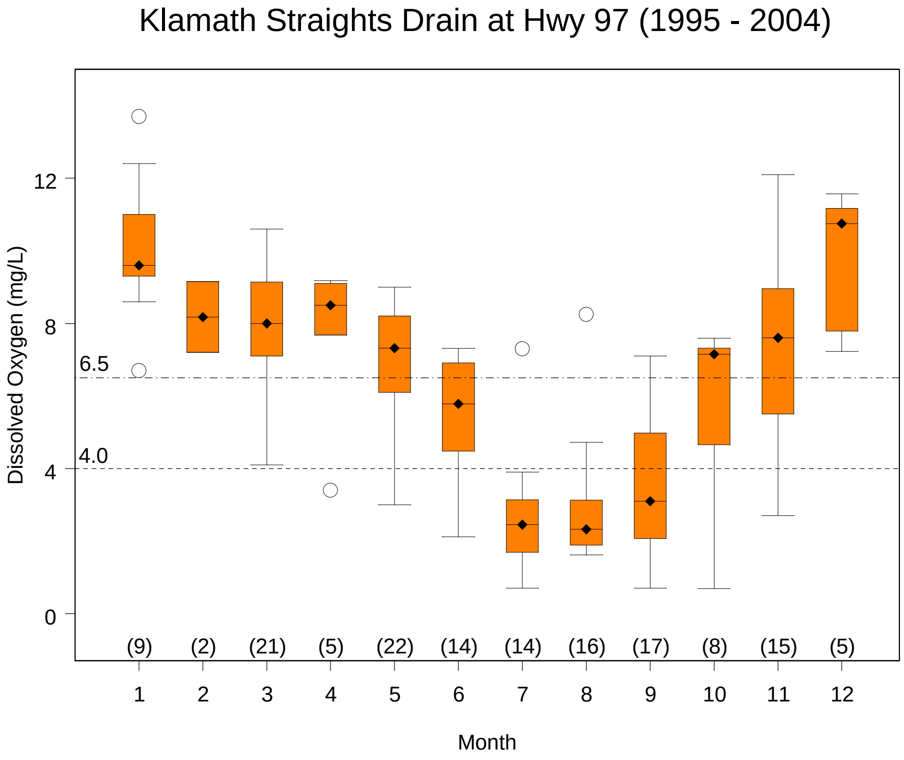


Figure 6. Seasonal Excursion Frequencies below Water Quality Standards for Dissolved Oxygen, Klamath Straits Drain at Highway 97. The horizontal lines denote the upper and lower range of Oregon's applicable dissolved oxygen standards.

CHAPTER 3: NUMERIC TARGETS

3.1 OVERVIEW OF NUTRIENT AND ORGANIC MATTER PROCESSES AND EFFECTS

Dissolved oxygen in water bodies may fall below healthy levels for a number of reasons including carbonaceous biochemical oxygen demand (CBOD) within the water column, nitrogenous biochemical oxygen demand (NBOD, also known as nitrification), algal respiration, zooplankton respiration and sediment oxygen demand (SOD). High water temperatures also reduce dissolved oxygen in water by decreasing oxygen solubility and increasing rates of nitrification and organic matter decay.

Nutrients

Nutrient loading encourages plant and algal growth. Preferred nutrient forms are inorganic phosphorus (measured as dissolved orthophosphate as P or soluble reactive phosphorus) and inorganic nitrogen (comprised of ammonia, nitrite, and nitrate). There are a number of natural processes that can increase nutrient loads to a river: leaching from the soil, degradation of plant material, and fish returning from the ocean to spawn. As the algae grow, they consume phosphorus and nitrogen. As algae die off, nutrients are released back into the river. Algae consume nitrogen and phosphorus at a fixed ratio. Therefore, if one nutrient is in short supply, it will often limit the growth of algae regardless of the concentration of the other nutrient. Analysis of available data indicates that nitrogen is the nutrient most limiting growth in the Lost River (Figure 7). Modeling analysis conducted for these TMDLs found that reductions in phosphorus loads would have little, if any, effect on algal growth rates or dissolved oxygen deficits; in contrast, reductions in nitrogen loads were found to be effective in reducing excess algal growth and maintaining acceptable dissolved oxygen levels. The growth of attached algae can also be limited by available suitable substrate, light, and temperature.

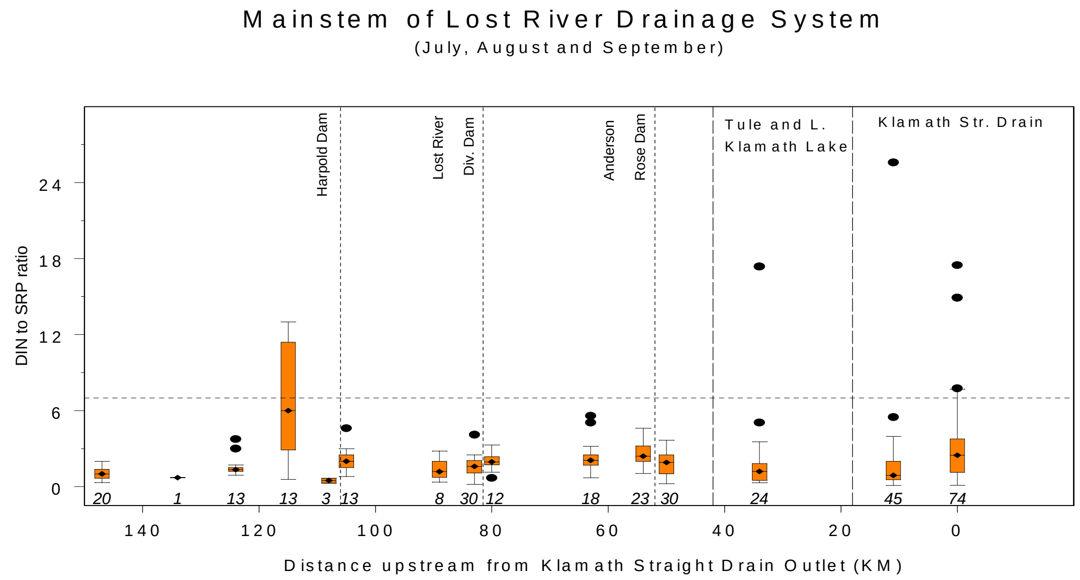


Figure 7. Longitudinal plot of the ratio of dissolved inorganic nitrogen (DIN) to soluble reactive phosphorus (SRP). The horizontal line represents a ratio of 7. Points above this line indicate possible phosphorus limitation, whereas points below this line indicate possible nitrogen limitation.

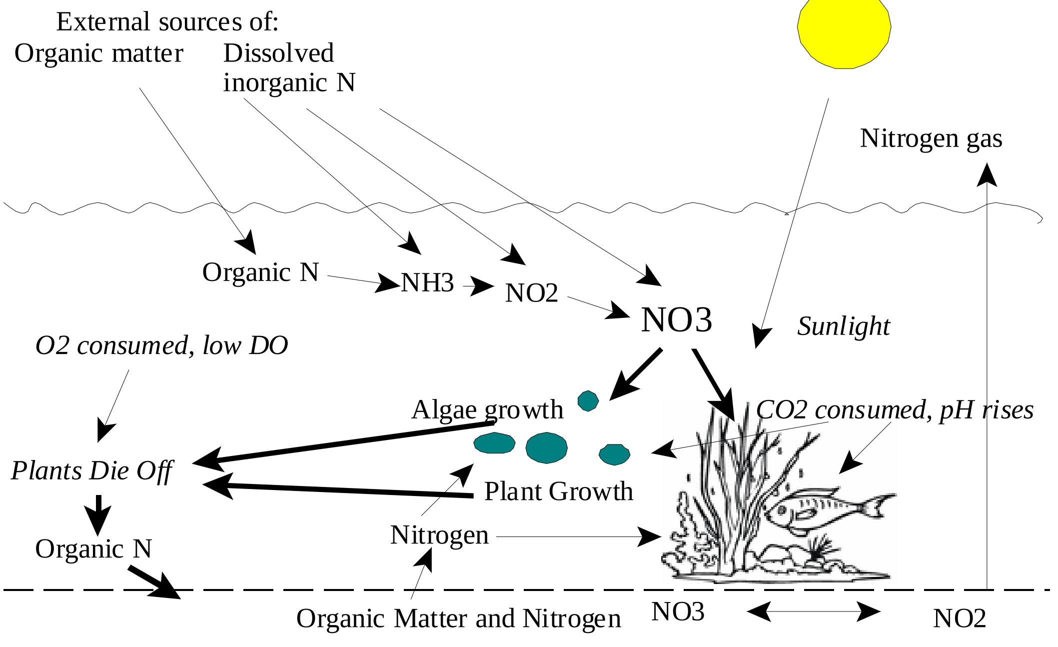
In water bodies, nitrogen is found in several compounds including ammonia (NH_3), nitrate (NO_3) and nitrite (NO_2) as well as in carbon-containing molecules. At appropriate levels, nitrogen-containing compounds are needed as part of a healthy aquatic food web, but excessive fertilization of a water body with nitrogen can increase plant and algae growth to unhealthy levels. High algal biomass levels can cause or contribute to nocturnal dissolved oxygen sags. The high consumption of oxygen by algae and plants at nighttime, and by bacteria as the excess plant material decays, can lead to the death of other aquatic organisms due to the low levels of oxygen remaining in the water. The major sources of nitrogen in water include agricultural return flows and runoff, municipal and industrial wastewater, failing septic systems, and animal waste runoff. Delivery of nitrogen to the Lost River can occur through tributaries, canals, drains, shallow and deep groundwater, and by nitrogen fixation from the atmosphere. Nitrogen loading quantified by input source is presented in Chapter 4.

Nitrogen moves among the atmosphere, soil, water, and organisms in a process called the nitrogen cycle. This cycle consists of five processes: nitrogen fixation, mineralization, nitrification, immobilization, and denitrification (Table 2 and Figure 8). Three of these processes are important in considerations of excess nitrogen, namely nitrogen fixation, nitrification and denitrification (Novotny and Olem, 1994).

Table 2. Nitrogen Cycle Processes

Reaction	Formula	O_2 Environment	Biological Mediator
Fixation	$N_2 \leftrightarrow$ organic N	Aerobic	Bacteria
Mineralization	organic N $\leftrightarrow NH_3$, NH_4	Both	Bacteria
Nitrification	$NH_4 \leftrightarrow NO_2^{-2} \leftrightarrow NO_3^-$	Aerobic	Bacteria
Immobilization	NO_3^-, NH_4^- $\leftrightarrow$ organic N	Aerobic	Plants, bacteria
Denitrification	$NO_3^- \leftrightarrow NO_2^{-2} \leftrightarrow N_2$	Anaerobic	Bacteria

Figure 8. Nitrogen and BOD Cycle in Lost River



Nitrogen fixation is the conversion of atmospheric nitrogen gas to ammonia (NH3) and then to organic forms usable by plants. There are two main processes through which nitrogen fixation occurs: lightning and biological fixation. Biological fixation is the more important process in terms of anthropogenic increases in nitrogen in the Lost

River Subbasin. The enzyme nitrogenase found in the bacteria of the genus *Rhizobium* mediates biological fixation. Biological fixation is an oxygen-dependent reaction and therefore is prevalent in legumes growing in aerated, upland soils.

The biological oxidation of ammonium (NH_4^+) to nitrite (NO_2^{2-}) and then to nitrate (NO_3^-) is the process called nitrification. Ammonium and nitrite exist in soils but are unstable molecules that readily accept oxygen, leaving nitrate as the dominant form of nitrogen in aerated soils. Denitrification is the process whereby certain species of facultative and anaerobic organisms reduce nitrate and nitrite to molecular nitrogen or nitrogen oxides. Under anaerobic conditions, nitrates are subject to high rates of denitrification. Denitrifying bacteria occur in wetlands and poorly drained soils.

Soil nitrate remains soluble in aqueous solutions and available for plant root uptake. Consequently, nitrate is the most important form of nitrogen in terms of agriculture. However, because nitrate is readily water-soluble, it is subject to high rates of leaching out of the soil and into groundwater and streams. Aquatic plants take up nitrogen in the form of dissolved inorganic nitrogen (nitrate, nitrite and ammonia). For this reason, these TMDLs focus upon control of dissolved inorganic nitrogen. Although particulate forms of nitrogen and phosphorous are believed to be far less important influences on growth of aquatic plans, these TMDLs indirectly account for particulate nutrients by also targeting excess loads of organic materials that may contain particulate nutrients.

Biochemical Oxygen Demand

When organic material is discharged into a water body, bacteria in the water work to break down the organic material through chemical processes that consume oxygen from the water column. This oxygen-consuming process is referred to as carbonaceous oxygen demand or CBOD. Water quality analysis of the Lost River system indicate that CBOD is a major cause of dissolved oxygen depletion.

Similarly, when solids that contain organic matter settle to the bottom of a stream they may decompose anaerobically (with no oxygen present), or aerobically (in the presence of oxygen), depending on conditions. The oxygen consumed in aerobic decomposition of these sediments is called sediment oxygen demand (SOD) and represents a loss of dissolved oxygen for a stream. SOD is an important cause of decreased oxygen levels in water, particularly in impoundments where water velocities are low. The SOD can continue to reduce dissolved oxygen for a long period after the pollution discharge ceases (e.g., organic-containing sediment deposited as a result of rain-driven runoff may remain a problem long after the rain event has passed). In contrast, carbonaceous biochemical oxygen demand (CBOD) and nitrification processes are typically short-term.

External sources of organic sediments include runoff and return flows from farms, rangeland, forest, and urban lands and wastewater treatment plant upsets. Internal sources include dead and dying aquatic plant and algae that has settled. It is not feasible to precisely quantify the organic sediment sources for this project given the complexity of the Lost River and limitations in some loading data. Control of the sources that deliver nitrogen and CBOD to the Lost River will also reduce the loading of settleable organics that cause SOD. The TMDL modeling analysis indicates that actions taken to reduce CBOD and nitrogen loading will sufficiently reduce loads of settleable organic materials such that all applicable water quality standards can be attained.

Dominant Aquatic Plants and Algae Species

A survey was conducted at ten sites in the Lost River of Oregon and California in July 2004 to determine the nature of the aquatic plant communities in the river system. The dominant taxa were *Ceratophyllum demersum* (coontail). *Lemna minor* (duckweed) was also common at many of the sites. Additional taxa included several species of pondweed (*Potamogeton pectinatus, P. crispus, and P. nodosus*), *Elodea canadensis*, and *Heteranthera dubia*. *Cladophora sp.*, a filamentous algae also common in nutrient-rich waters, was also present at a number of sites, commonly attached to the macrophytes (non-microscopic, aquatic plant life) present. All of these taxa found in the Lost River are tolerant of high turbidity and are common species found in eutrophic lakes and slow-moving waters. The chemical analysis of the plants indicated that they were generally nitrogen-deficient based on ratios of nitrogen to phosphorus in the plant tissue (Eilers 2005).

3.2 NUMERIC TARGETS

Numeric targets are established for water quality indicators, based on the applicable water quality standards, to represent the goals of the TMDL and provide indicators that can be monitored to assist in evaluating the future effectiveness of DIN and CBOD reductions in achieving water quality standards. As discussed in Sections 1 and 2, these TMDLs are being developed to address violations of applicable numeric water quality standards for dissolved oxygen and pH and narrative nutrient standards. As the Basin Plan specifies numeric objectives for both dissolved oxygen and pH, these numeric values will serve as the numeric targets for the TMDL analysis. These targets are applicable for the entire Lost River system in California, including:

1- Lost River from the Oregon border to Tule Lake Refuge,
2- Tule Lake Refuge,
3- Lower Klamath Refuge, and
4- Straits Drain from Lower Klamath Refuge to Oregon border.

The numeric targets are specified in Table 3.

Table 3. Numeric Targets

Indicator	Numeric Target Value
Dissolved Oxygen	Greater than or equal to 5.0 mg/l (daily minimum)
pH	No higher than 9 as daily maximum or lower than 7 as a daily minimum

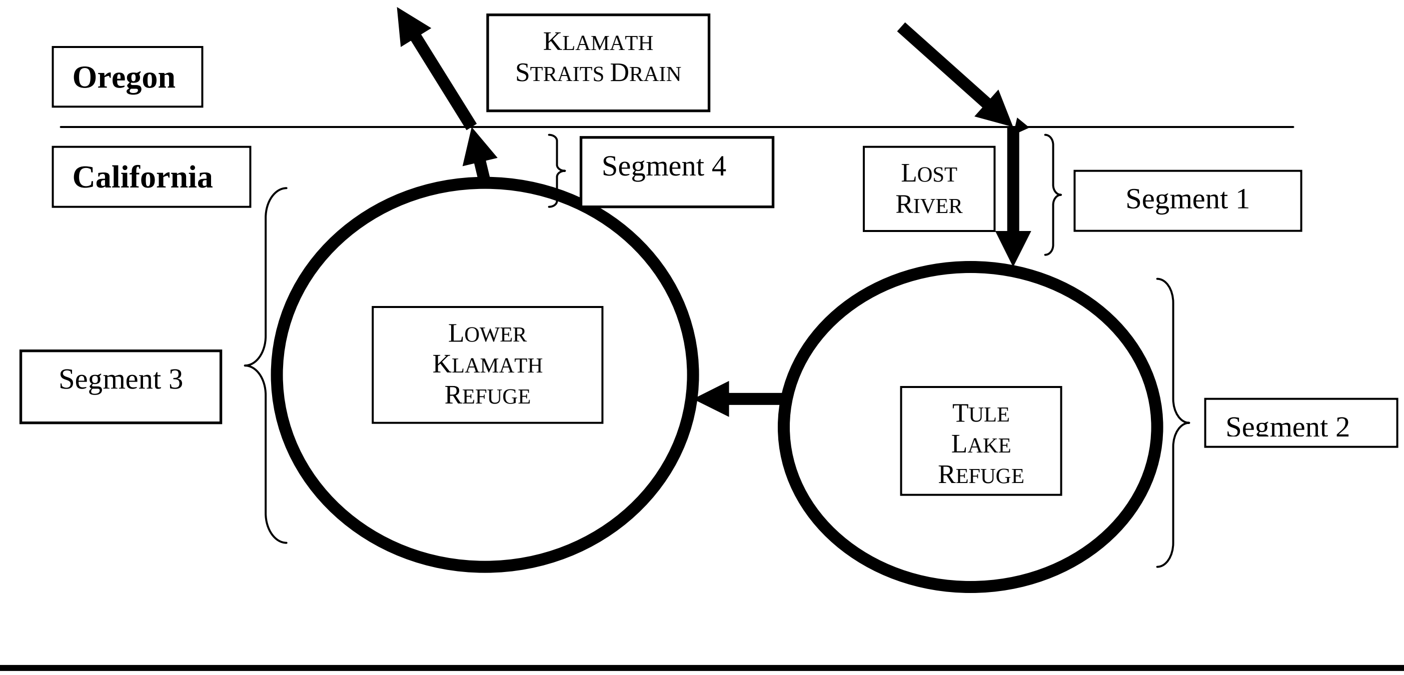
As discussed in Section 3.1, low dissolved oxygen and elevated pH conditions are associated with excessive loads of DIN and CBOD to the Lost River system. The TMDL modeling analysis was designed to identify the DIN and CBOD reductions needed to bring about attainment of the dissolved oxygen and pH standards. While it would be desirable to specify maximum DIN and CBOD targets to supplement the dissolved oxygen and pH targets, it was infeasible to do so for these TMDLs, as there is substantial spatial and temporal variability in the manner in which oxygen and pH levels are affected by nitrogen and organic matter loads.

CHAPTER 4: SOURCE ANALYSIS

4.1 OVERVIEW OF SOURCE ANALYSIS

Estimates of nitrogen and CBOD loads were developed for several discrete areas of the Lower Lost River system in California. Loading estimates were developed for each of the sources to which load and wasteload allocations are assigned through the TMDL decisions in Chapter 6. The Lost River study area was divided into 4 “segments” for purposes of presenting loading estimates and the associated TMDLs and allocations (see Figure 9). The largest estimated source of nitrogen and CBOD loading is agricultural drainage flows into Lost River. Loading sources and the methods used to estimate loads are discussed below; Table 4 presents the loading estimates for each source.[7]

Figure 9. Lost River TMDL Segments



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[7] There are naturally occurring sources of nitrogen and organic matter in the Lost River system, including fecal material from birds and wildlife. As these sources are largely uncontrollable, the model generally accounts for naturally occurring sources but was not designed to provide for reductions in these sources.

These estimates were based on modeling results and water quality data analysis that examined DIN and CBOD levels in Lost River between Anderson Rose Dam in Oregon and Tule Lake Refuge in California. The TMDL analysis focused upon 1999 as the “baseline” year because (a) the most extensive data set was available for this year, and (b) 1999 was a year in which water quality impairment was particularly pronounced. The analysis also used data from subsequent years (2004, in particular) to support model validation. Available data, particularly concerning flows and nutrient loads from agricultural return flows were limited for this analysis, but sufficient water flow and quality data were available to build a reliable water quality model of the system. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005 and Tetra Tech, 2006. Pollutant loading data for each area covered by the TMDLs were limited; therefore, it was necessary to estimate loads for many sources through analysis of modeling results and the limited loading data that were available.

Table 4. Nitrogen and CBOD Loading Estimates (based upon 1999 data)

Segment	Source	DIN Loads (mtons/yr)	C-BOD Loads (mtons/yr)
1	Lost River at Stateline Road (OR Border)	55	108
	Agricultural drainage loads to Lost River between Stateline Road and Tule Lake Refuge	2	35
	CalTrans Roads and Facilities to Lost River between Stateline Road and Tule Lake Refuge	0.1	0.2
2	Background load from Lost River	57	143
	Agricultural and refuge drainage loads to Tule Lake Refuge	74	514
	CalTrans Roads and Facilities to Tule Lake Refuge	0.1	0.2
	City of Tulelake Treatment Plant	2	7
3	Background load from Tule Lake Refuge	39	492
	Agricultural and refuge drainage loads to Lower Klamath Lake Refuge	8	79
	Load from Ady Canal to Lower Klamath Lake Refuge	9	79
	CalTrans Roads and Facilities to Lower Klamath Lake Refuge	0.1	0.2
4	Background load from Lower Klamath Lake Refuge	40	387
	Drainage loads to Straits Drain from Lower Klamath Lake Refuge to OR Border	3	21

4.2 DESCRIPTION OF SOURCE CATEGORIES

“Background” Loads from Oregon at Oregon/California Border

Load allocations for these “upstream” loads in Lost River at the California-Oregon border segment are assigned to the State of Oregon. This approach helps ensure that all of the sources of nitrogen and CBOD loading bear a share of the responsibility for reducing pollutant loads as necessary to implement the TMDLs. We understand that the State of Oregon plans to develop TMDLs for DIN and CBOD for Lost River in Oregon in the near future. Through the Oregon TMDL process, allowable loads from individual pollutant loading sources within Oregon will be identified through the allocation process. Nitrogen and CBOD loads from areas upstream from the border apparently come from several sources, including but not limited to irrigation return flows, other runoff sources, wildlife, and sources discharging to Upper Klamath Lake and the Klamath River.

Agricultural Drainage Discharges to Lost River, Oregon Border to Tule Lake Refuge

As direct loading data were unavailable for this analysis, these loads were estimated by calculating the difference between DIN and CBOD loads in Lost River at the Oregon border and at the beginning of Tule Lake Refuge. This approach assumes pollutant levels are conservative. Moreover, as the modeling analysis focused upon a segment from Anderson Rose Dam to Tule Lake that crosses the Oregon-California border, loadings to this segment in California are proportional to the length of the segment located in California (about one-third of its length). The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 25-26 and Tetra Tech, 2006. Inputs to this segment are from lands and drains in the Tulelake Irrigation District (TID); hence the load allocations are assigned to TID. As TID receives water supply and drain water from Klamath Irrigation District (KID) facilities in Oregon, an unknown portion of the DIN and CBOD load discharged to this segment of Lost River may originate in KID facilities. As discussed in Chapter 7, additional water quality and flow monitoring in the supply and drainage system is needed to more accurately characterize the relative loading contributions from the different irrigation districts and refuge areas to this segment of Lost River.

Agricultural and Refuge Drainage Discharges to Tule Lake Refuge

As direct loading data were limited for this analysis, these loads were estimated by calculating the difference between DIN and CBOD loads to and from Tule Lake Refuge area, and assuming the difference is comprised of loads from agricultural drainage or refuge operation discharges to the Tule Lake sumps. This approach assumes pollutant levels are conservative. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 26-27 and Tetra Tech, 2006. Internal nutrient loadings to Tule Lake were not quantified in this analysis. Over the long run, however, internal loading rates will likely decrease as the amount of excessive nutrient loadings from external sources are decreased.

Inputs to this segment are from lands and drains in the TID or that are part of the Tule Lake National Wildlife Refuge; hence the load allocations are assigned jointly to TID and USFWS. However, as TID receives water supply and drain water from Klamath Irrigation District (KID) facilities in Oregon, an unknown portion of the DIN and CBOD load discharged to Tule Lake Refuge from TID facilities originates in KID facilities. Moreover, insufficient data are currently available to distinguish pollutant loads from TID and Refuge operations. As discussed in Chapter 7, additional water quality and flow monitoring in the supply and drainage system is needed to more accurately characterize the relative loading contributions from the different irrigation districts and wetlands areas to Tule Lake Refuge.

City of Tulelake Sewage Treatment Plant

The City of Tulelake operates a 0.16 million gallon per day (mgd) sewage treatment plant that discharges to a drain that is tributary to Tule Lake Refuge. Existing CBOD loads were estimated based on existing National Permit Discharge Elimination System (NPDES) permit limitations. Existing DIN loads were estimated based on facility monitoring data (St. John, 2006).

Loadings from Tule Lake Refuge

Estimates of loads from Tule Lake Refuge are based on monitored flow and pollutant concentration data collected at Pumping Station D to P-Canal. These values were used to calibrate the water quality model as discussed in Chapter 5 and set the “background” loads included in the Lower Klamath Refuge TMDLs. It appears there are no direct loadings to P-Canal other than pumping from Tule Lake Refuge. Therefore, no separate load allocations are established for loads to P-Canal. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 26 and Tetra Tech, 2006.

Agricultural and Refuge Loadings to Lower Klamath Refuge

As direct loading data were limited for this analysis, these loads were estimated by calculating the difference between DIN and CBOD loads to and from Lower Klamath Refuge, and assuming the difference is comprised of loads from agricultural drainage discharges and refuge operations to Lower Klamath Refuge. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 27-28 and Tetra Tech, 2006. Internal nutrient loadings to Lower Klamath Refuge were not quantified in this analysis. Over the long run, however, internal loading rates will likely decrease as the amount of excessive nutrient loadings from external sources are decreased.

Inputs to this segment are from wildlife refuge and agricultural lands and drains in the Lower Klamath Refuge; hence the load allocations are assigned to USFWS in its capacity of Refuge manager. Insufficient data and information were available to distinguish relative loading contributions from agricultural operations and other refuge operations. As discussed in Chapter 7, additional monitoring is warranted to distinguish the contributions of nitrogen and BOD loading from different sources.

Loadings from Ady Canal to Lower Klamath Refuge

The Ady Canal was constructed in 1912 by the Klamath Drainage District to divert water from Keno Reservoir on the Klamath River to agricultural operations and, later, during the fall-spring period, to the Lower Klamath National Wildlife Refuge. Loads to the Refuge from Ady Canal were estimated based on flow and loading data. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 27-28 and Tetra Tech, 2006. Ady Canal is operated by the U.S. Bureau of Reclamation (USBOR); hence the load allocations are assigned to USBOR in its capacity of Canal manager.

Loadings from Lower Klamath Refuge

Estimates of loads from Lower Klamath Refuge are based on monitored flow and pollutant concentration data collected at the outlet of Lower Klamath Refuge. These values were used to calibrate the water quality model as discussed in Chapter 5 and set the "background" loads included in the Straits Drain TMDLs. The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 27-28 and Tetra Tech, 2006.

Agricultural Drainage Loads to Straits Drain in California

As direct loading data were limited for this analysis, these loads were estimated by calculating the difference between DIN and CBOD loads at Pump Station E and loads from Lower Klamath Refuge, and assuming the difference is comprised of loads from agricultural drainage discharges primarily from refuge leased lands to this segment of Straits Drain. Moreover, as the modeling analysis focused upon a segment from Lower Klamath Refuge to Pump Station E that crosses the Oregon-California border approximately 1-2 miles north of Lower Klamath Refuge, estimated loadings to this segment in California are proportional to the length of the segment located in California (approximately 10% of segment length). The analytical basis for these estimates is discussed in more detail in Tetra Tech, 2005, p. 28 and Tetra Tech, 2006. The Straits Drain is jointly operated by the U.S. Bureau of Reclamation (USBOR) and USFWS; hence the load allocations are assigned to both USBOR and USFWS.

Stormwater Discharges from CalTrans Facilities

Stormwater discharges from roads and other facilities managed by CalTrans are regulated under an NPDES statewide permit. Although two State highways are present in the TMDL project area, their spatial extent is very limited and nitrogen and BOD discharges are expected to be relatively insignificant. A rough estimate of loads was developed based on best professional judgment, and wasteload allocations are provided in each of the TMDLs to account for these very small pollutant contributions.

CHAPTER 5: LOADING CAPACITY LINKAGE ANALYSIS

This chapter discusses the use of water quality models to evaluate nutrient and BOD loads and effects in the Lost River system, and their use to determine the capacity of the system to receive loadings of DIN and CBOD and achieve attainment of the applicable water quality standards for dissolved oxygen and pH. Federal regulations define "loading capacity" as "*the greatest amount of loading that a water can receive without violating water quality standards*." (40 CFR 130.2(f)). The load capacity analysis serves to link water quality goals with pollutant loading information in order to determine necessary loading reductions.

5.1 DATA AND MODELING ANALYSIS

As a first step in developing an understanding of current water quality conditions in the Lost River system, data were obtained from numerous sources and multiple water quality monitoring events. Every attempt was made to obtain the most current and comprehensive data to support water quality model development, application, and analysis. The technical analysis used to develop the TMDLs made the best use of available data and provides a framework that can be readily updated in the future as more data become available.

Using available information, a hydraulic and water quality model was developed to: 1) analyze the available data; 2) simulate water quality dynamics in the system, and 3) predict conditions that attain water quality criteria. Modeling results indicate that water quality standards can be attained by reducing loading of nitrogen and associated biochemical oxygen demand.

To support TMDL development for the Lost River system, the U.S. Army Corps of Engineers' CE-QUAL-W2 (W2) model was used for the Lost River system from Malone Dam through the Lower Klamath Refuge, as well as the Klamath Straits Drain.[8] W2 is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole and Wells 2003). Complete documentation of modeling configuration, model input, and calibration is presented in Model Configuration and Results Lost River Model for TMDL Development (Tetra Tech 2005).

5.1.1 Model Configuration

For this modeling study, the Lost River was divided into 12 waterbody segments based on the presence of major hydraulic features and the location of monitoring data in the system (Figure 10). Within the W2 model, each computational segment can have multiple layers associated with it. The layers are horizontal "slices" of the water column from top to bottom that assist the model in accurately characterizing nutrient, BOD, and dissolved oxygen flux at different water body depths. Each modeled waterbody had from 2 to 5 layers. For this study, layer thicknesses were set to approximately 1 meter (and ranged from 0.84 meters to 1.15 meters) for the 12 waterbodies (Table 5). As insufficient information was available to support more detailed delineation of Tule Lake and Lower Klamath Lake/Refuge into multiple segments, the lakes were represented in the model as single computational segments. See Tetra Tech, 2005, p. 13 for further information concerning lake segmentation.

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[8] The water quality and hydraulic model was developed for the entire Lower Lost River in Oregon and California to support a comprehensive analysis of nutrient issues in the Lost River system and to support eventual TMDL development in Oregon.

Table 5. Model Configuration

Waterbody Number	Location	Number of Segments	Segment Length (m)	Layers	Thickness of Layers (m)
1	Malone to Harpold	80	483	5	1.0
2	Harpold to RM 27	10	489.7	4	0.96
3	RM 27 to Wilson Reservoir	30	505.3	4	0.84
4	Wilson Reservoir	9	506.4	5	1.0
5	Wilson Dam to Anderson Rose Dam	55	534.5	5	1.0
6	Anderson Rose Dam to Tule Lake	24	502.9	4	1.0
7	Tule Lake	1	8008.0	2	1.0
8	P-Canal	8	502.6	3	1.0
9	Lower Klamath Lake	1	11898	2	1.0
10	Klamath Straits Drain at Pump E	13	507.2	5	1.15
11	Klamath Straits Drain at Pump F	15	538.1	5	0.93
12	Klamath Straits Drain D/S Pump F	6	503.2	5	0.93

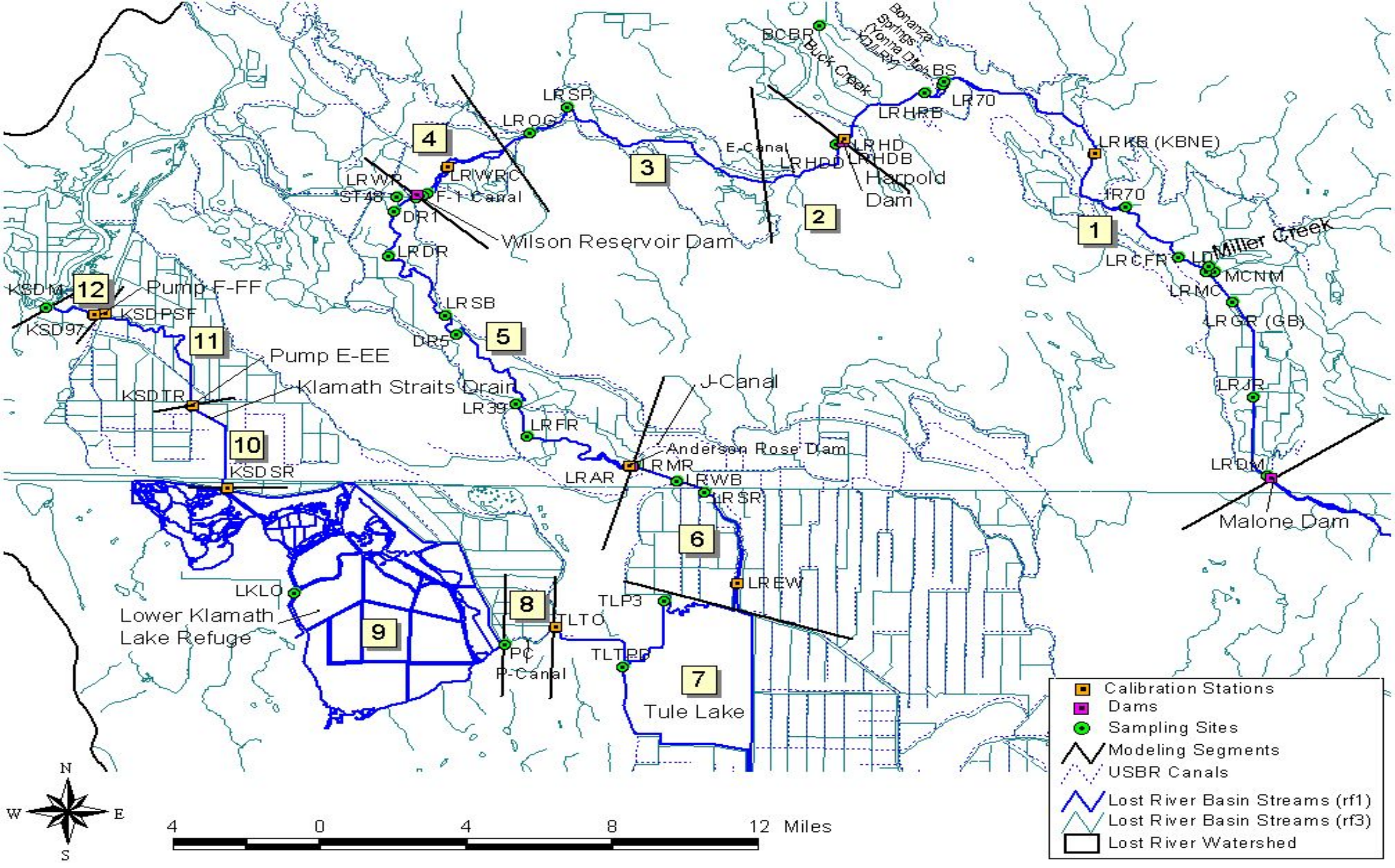

Figure 10. Map of Modeled Segments

5.1.2 Model Boundary Conditions and Linkages

To run the dynamic W2 model, external forcing factors, known as boundary conditions, and internal linkages must be specified for the system. These forcing factors are a critical component in the modeling process and have direct implications on the quality of the model's predictions. External factors include a wide range of dynamic information:

- Upstream external inflows, temperature, and constituent boundary conditions (US);
- Tributary inflows, temperature, and constituent boundary conditions (TRIB);
- Distributed tributary inflows, temperature, and constituent boundary conditions (DST);
- Withdrawals (WD); and
- Atmospheric conditions (including wind, air temperature, solar radiation).

Upstream external inflows represent the inflow at the model's "starting" point. Tributary inflows represent the major tributaries that feed into the Lost River. Distributed tributary inflows represent the combination of all diffuse contributions to each of the waterbodies (i.e., anything that is not considered a major tributary inflow, such as irrigation return flow). All water removed from the system is combined within the Withdrawals category. The US, TRIB, DST, and WD boundary conditions are specified for the Lost River model based on all available data (Figure 11). The model also must account for linkages within the system between the 12 waterbodies. Modeled internal linkages include:

- Downstream weir-based boundary conditions (DSW);
- Upstream internal flow, temperature and constituent boundary conditions (USIFB);
- Downstream internal head boundary conditions (DSIH); and
- Upstream internal head boundary conditions (USIH).

5.1.3 Model Assumptions

All mathematical water quality models are a simplified representation of the very complex real world. The Lost River system is certainly no exception. It is a highly modified environmental system driven largely by irrigation operations, and it exhibits tremendous biological activity. Due to a lack of quantitative data to describe many aspects of the system, a number of key assumptions were made during model development. A complete list of all modeling assumptions and limitations is presented in Model Configuration and Results Lost River Model for TMDL Development (Tetra Tech 2005)

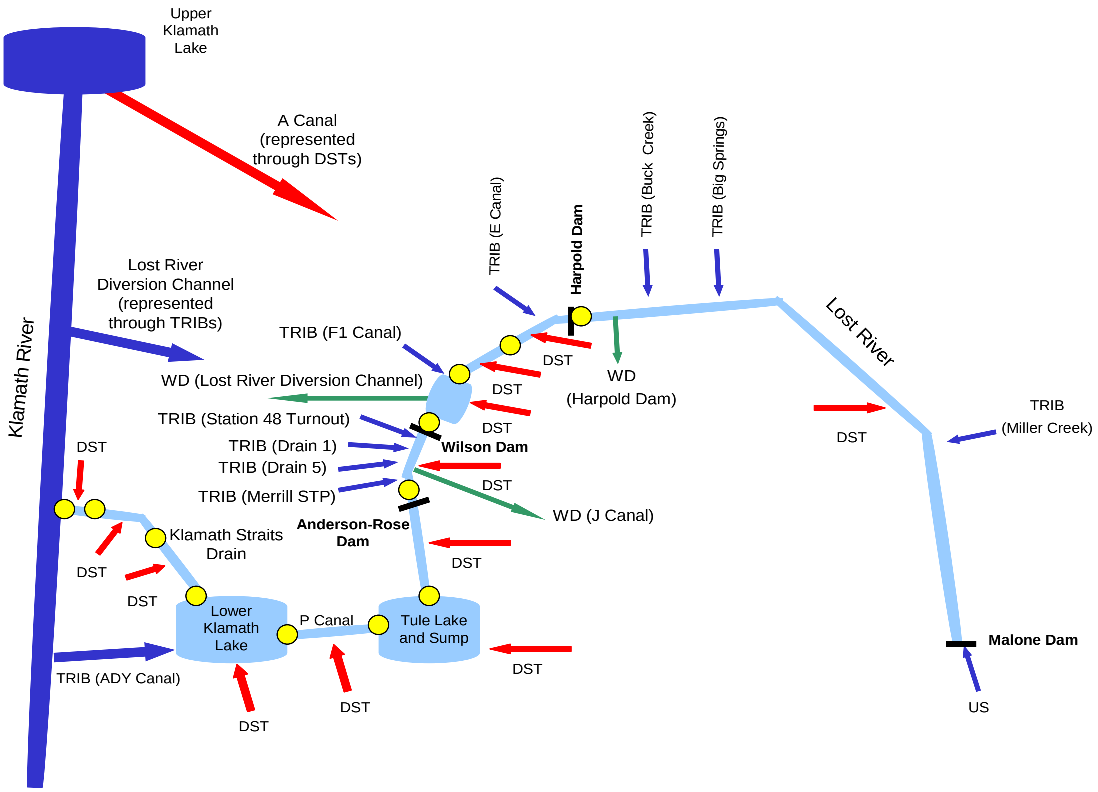

Figure 11. Model Boundary Conditions and Linkages. Yellow circles represent waterbody divisions. Blue arrows represent tributary (TRIB) and upstream (US) inputs. Red arrows represent distributed (DST) inputs. Green arrows represent withdrawals (WDs).

Key assumptions associated with Lost River model development are as follows:

- Ungaged inflows and outflows can be estimated using a water balance based on measured flows, inflows and outflows.
- Due to the lack of quantitative data for characterizing agricultural pumping, return flow and other unknown sources and sinks, it was assumed that the water quality associated with the distributed flow is similar to the water quality in the Lost River where the distributed flow discharges.
- One phytoplankton species and one macrophyte species are sufficient for representing the overall primary production and nutrient interactions in the system.
- The water quality gradient within Tule Lake and Lower Klamath Lake is insignificant; therefore; each can be considered as a single, mixed segment.

5.1.4 Model Limitations

The capability of a model is constrained by the availability and quality of data. Consequently, the Lost River model is not expected to be able to mimic the exact timing and location of all water quality conditions and/or flow from return flows. However, the model can be used to represent the overall water quality trends in response to external loading and internal system dynamics. However, as water quality standards exceedances are not expected to be highly sensitive to short-term variations in nutrient inputs, the model is also capable of evaluating loading and water quality response and is appropriate to use to develop the TMDL.

The model predicts some water quality standards may be exceeded under the TMDL scenario due to model and boundary condition uncertainty. Ammonia toxicity model predictions were found to exceed limits in the spring upstream of Tule Lake Refuge. These high values are likely an artifact of the model construction, which was based on sparse data during the spring, and are not believed to be representative of actual water quality conditions. A review of the monitoring data for this period indicates that there were no apparent ammonia toxicity issues in the Lost River in California. In general, however, the model did a very good job of representing water quality responses to changes in loads of nutrients and organic matter. The model provides a sound framework for developing TMDLs and allocations.

5.3 EVALUATION OF LOAD REDUCTION SCENARIOS

The calibrated hydrodynamic and water quality model CE-QUAL-W2 was used to evaluate attainment of water quality standards for the Lost River, Tule Lake Refuge, Lower Klamath Lake Refuge and Klamath Straits Drain. Modeling results indicate that the dissolved oxygen standards were the most stringent standards. Consequently, if the dissolved oxygen standards are met in the system, then the water quality criteria for pH and nutrients will also be attained. Starting from a depiction of current conditions, source loading was iteratively reduced through several pollutant reduction scenarios until water quality criteria were achieved in the Lost River. The scenario that serves as the basis for the TMDL and allocation decisions, referred to as "Scenario 1D" is described in Tetra Tech 2005 and Tetra Tech 2005(b). Graphical depiction of results from the scenario selected for TMDL calculation are presented in Figures 12 – 15.

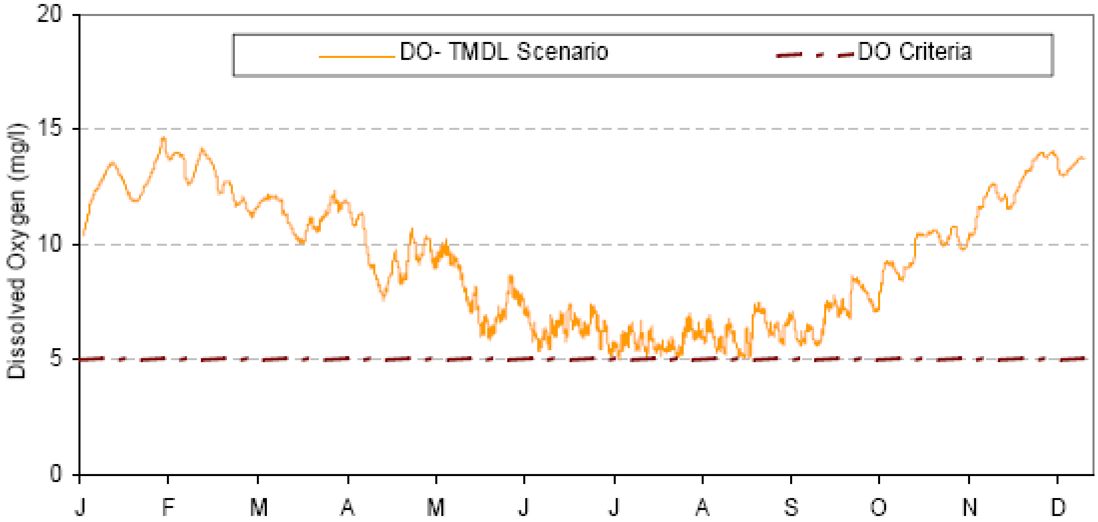

Figure 12. DO standard compliance – Lost River at Stateline Road (LRSR)

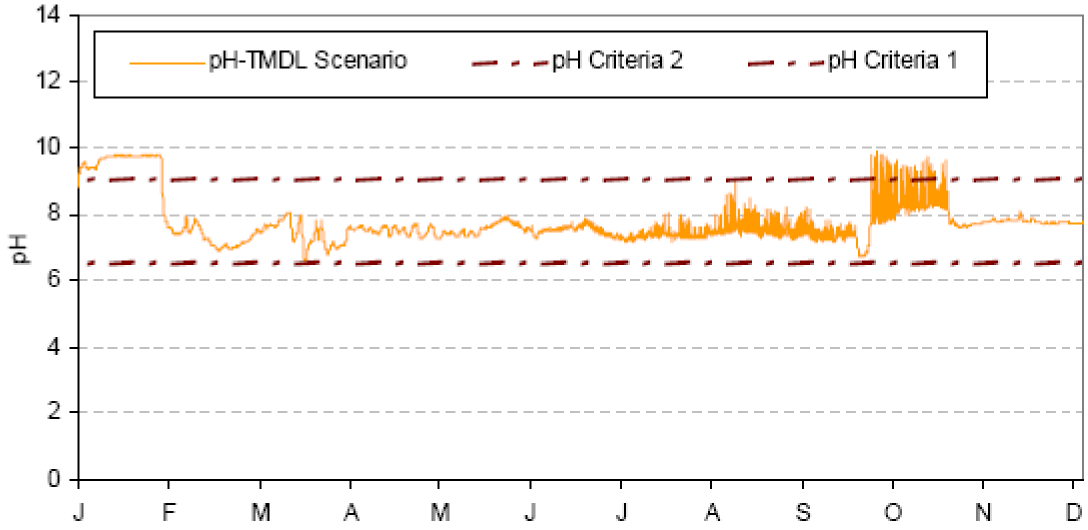

Figure 13. pH standard compliance – Lost River at Stateline Road . Exceedances of the 9.0 criteria in the winter and spring are believed to be artifacts of the coarse nature of the model boundary conditions.

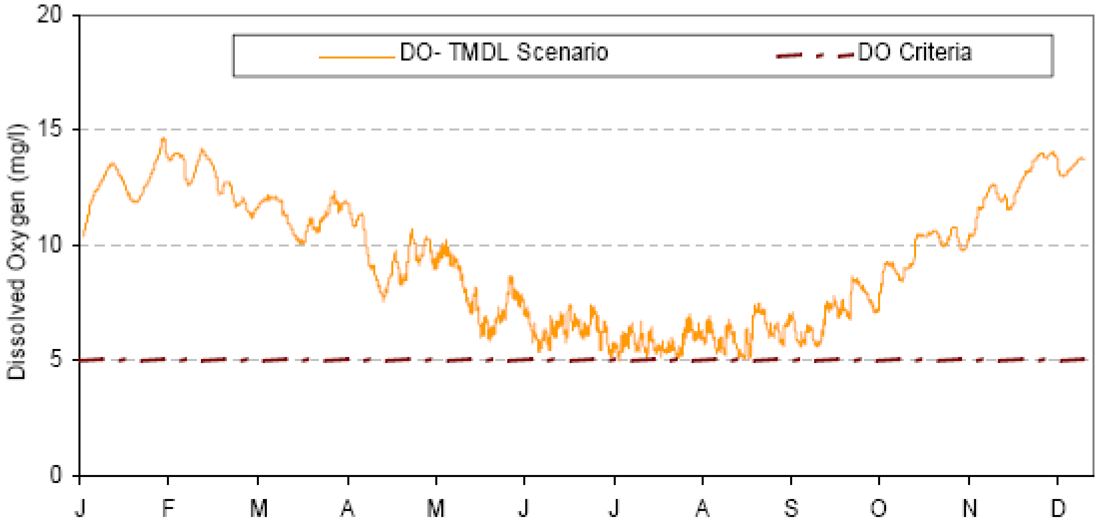

Figure 14. Dissolved oxygen standard compliance – Lower Klamath Lake (LKL).

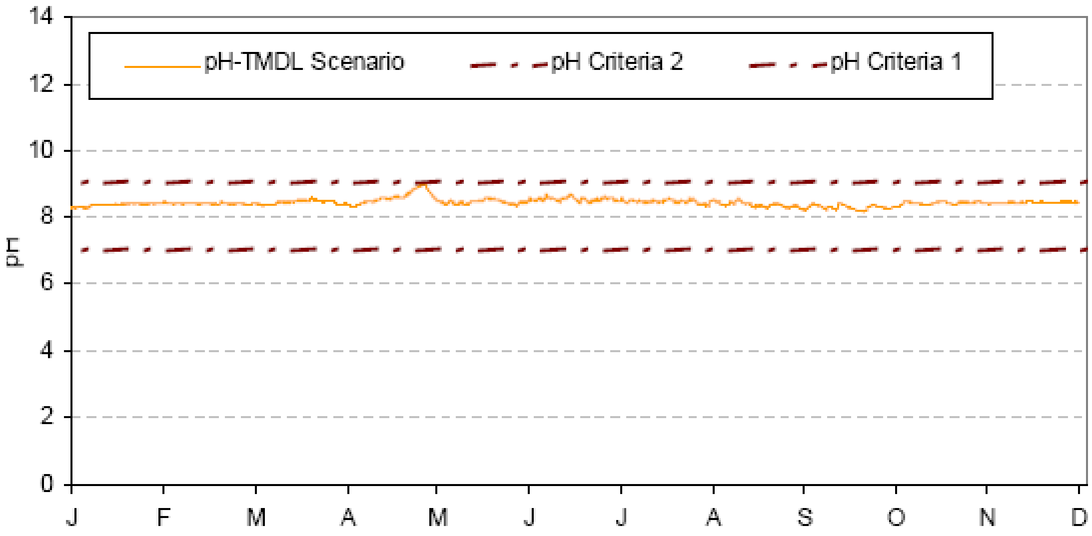

Figure 15. pH standard compliance – Lower Klamath Lake (LKL)

5.3 ESTIMATION OF LOADING CAPACITY

As discussed above, W2 modeling evaluation of scenario 1D in which DIN and CBOD inputs are reduced by 50% throughout the Lost River system in California concluded that water quality standards for dissolved oxygen and pH would be met at all locations in California. Therefore, the loading capacity of Lost River in each of the 4 evaluated segments is estimated to equal 50% of 1999 estimated loads presented in Table 4 above. This set of loading capacity estimates is used in the following chapter to define the TMDLs and associated allocations for each segment.

CHAPTER 6: TMDLS, ALLOCATIONS, AND MARGIN OF SAFETY

6.1 TMDLS AND ALLOCATIONS

The pollutant loading capacities established in Chapter 5 represent the maximum amount of DIN and CBOD that can be discharged such that Lost River can still attain the applicable water quality standards for dissolved oxygen and pH in California. The total maximum daily load (TMDL) is normally set equal to the loading capacity for each pollutant, as is the case with the Lost River TMDLs.

As discussed in Chapters 1 and 4, TMDLs are being set for four areas in the Lost River system in California corresponding to the different "segments" of the system in California (see Figure 9 on page 17 and Figure 16 below):

■ Segment 1. Lost River from the Oregon border to Tule Lake,
▨ Segment 2. Tule Lake National Wildlife Refuge,
▤ Segment 3. Lower Klamath National Wildlife Refuge, and
░ Segment 4. Straits Drain

The TMDLs for each segment are represented as the sum of allowable loads, also known as allocations, to each source of nitrogen and CBOD discharges to those segments. Figure 16 presents the approach used to subdivide the Lost River system in schematic form.

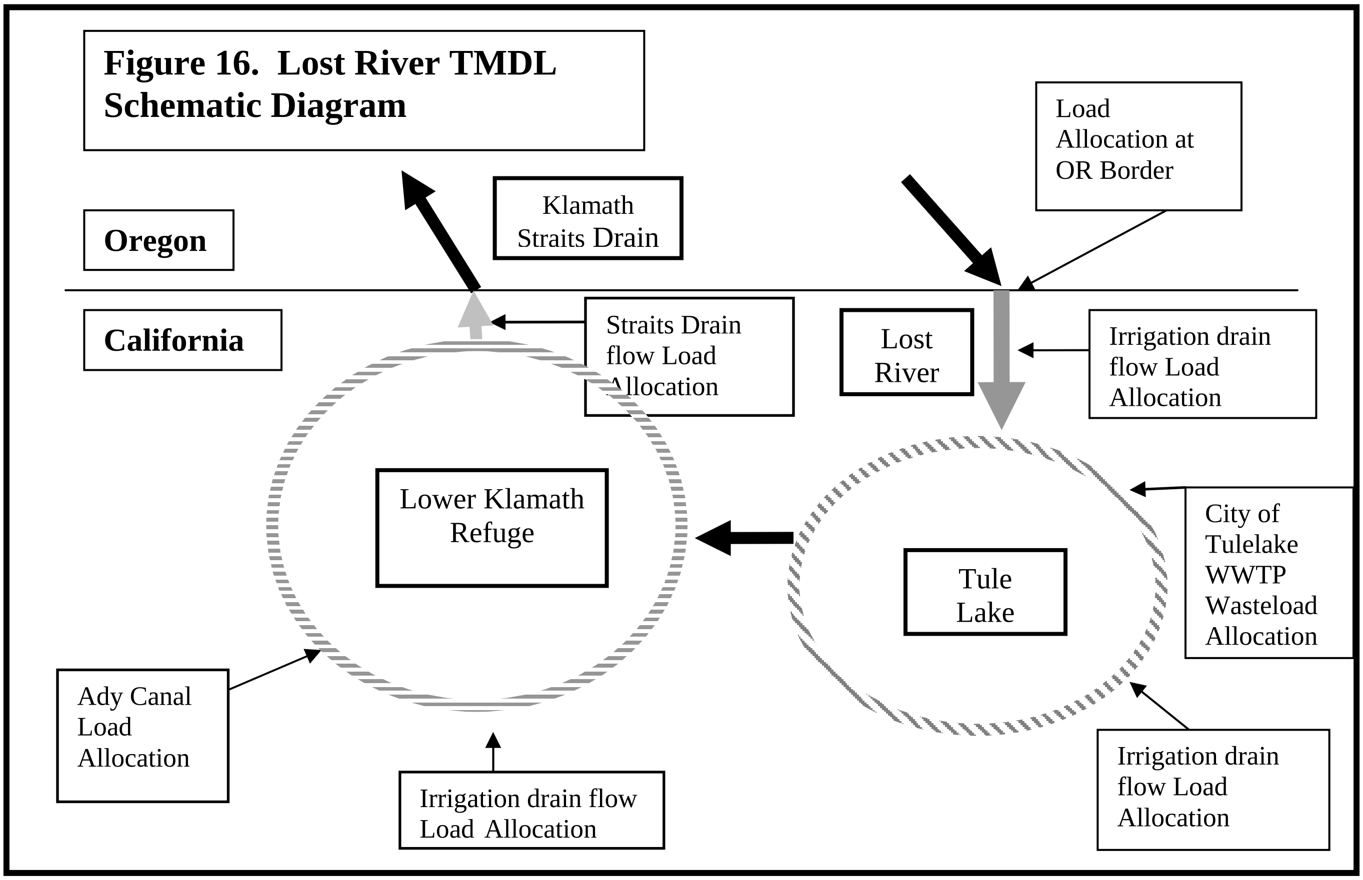

Figure 16. Lost River TMDL Schematic Diagram

TMDLs are defined as the sum of the wasteload and load allocations [40 CFR 130.2(i)]. Allocations are defined as the portion of a receiving water loading capacity that is allocated to point or non-point sources and natural background. A *Load Allocation* (LA) is the portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. A *Waste Load Allocation* (WLA) is the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Chapter 6 described the DIN and CBOD loading sources to which allocations are being assigned.

Table 6 presents the TMDLs and associated allocations. For each of the 4 segments for which TMDLs are established, load allocations are provided for nonpoint sources that discharge to the segment (termed agricultural drain flows here and “distributed” sources in the modeling analysis). Pursuant to federal regulatory provisions at 40 CFR 130.2(g), load allocations may be expressed as “gross allotments.” The load allocations in these TMDLs may be characterized as gross allotments as insufficient data and information are available to support further delineation of load allocations by specific source category. A separate load allocation is established for Ady Canal, which discharges to Lower Klamath Refuge. As discussed in Chapter 5, each of these allocations is set at approximately 50% of 1999 estimated loads presented in Table 4 above. Load allocations are also established for background loads to each segment (i.e., the estimated loads following the necessary 50% load reduction that come from the next upstream segment).

Load allocations are also established to address upstream loads from Oregon where the River flows into California. It is permissible and appropriate to set load allocations at upstream jurisdictional boundaries (at the Oregon border, in this case) as necessary to ensure TMDLs are set at levels sufficient to attain applicable water quality standards in the downstream jurisdiction (California, in this case). Load allocations have been set at upstream jurisdictional boundaries in several other TMDLs using the same approach used in these TMDLs. Even if projected load reductions are not met upstream, allocations in Table 6 will still be applicable.

Wasteload allocations are established for the two point sources that discharge nutrients and BOD in the study area—the City of Tulelake sewage treatment plant and CalTrans facility stormwater runoff. As the City of Tulelake is in the process of upgrading its treatment plant, its wasteload allocations are set at 50% of estimated current loadings to be consistent with the allocations set for nonpoint sources. We believe these wasteload allocations will be achievable by the new treatment plan. For CalTrans, the wasteload allocation is set at a level achievable through implementation of best management practices (BMPs) specified in the existing NPDES permit. These permitted BMPs must be applied in this watershed in order for these TMDLs to be implemented.

TMDLs, load allocations, and wasteload allocations are expressed both in terms of maximum annual and maximum average daily loads. The modeling analysis conducted to support the TMDLs indicates dissolved oxygen and pH levels vary substantially on a seasonal basis but less so on a daily basis. The period between spring through fall is associated with the most serious water quality violations. While there is seasonal variability in nitrogen and CBOD loading and effects, nitrogen and organic material discharged to Lost River may have lengthy residence times. As a result, pollutants discharged during the less critical period between late fall to early spring may remain in the system for substantial periods of time and contribute to adverse effects on dissolved oxygen and pH levels during the critical summer period. The TMDLs are set to require year-round pollutant loading reductions and are expressed, in part, in annual terms to reflect this requirement.

The TMDLs are designed to result in attainment of water quality standards at all locations in the receiving water body segments. TMDL attainment should be measured by evaluating:

1. Are the applicable dissolved oxygen and pH water quality targets met at all monitoring locations?
2. Have DIN and CBOD loads been reduced by 50% or more in comparison with 1999 baseline conditions?

If the followup analysis of monitoring data indicate the applicable water quality targets are regularly met, it would be reasonable to conclude the TMDL has been attained. If, however, the necessary 50% loading reductions have been attained yet the applicable water quality targets are not attained, it may be necessary to review and potentially revise the TMDLs to ensure sufficient pollutant reductions are being identified.

The TMDLs and allocations are also expressed in daily terms to focus attention on the need to avoid large pulses of nutrient loading that could cause or contribute to short-term dissolved oxygen deficits. Daily TMDLs and allocations were calculated by dividing the annual load-based TMDLs and allocations by 365. Setting the TMDLs and allocations in daily terms is more reflective of the averaging period specified for the numeric targets (Chapter 2). Finally, the importance of setting TMDLs in daily terms was recently reinforced by a federal Appeals Court decision in the recent Anacostia River TMDL case (*Friends of the Earth, Inc. v. EPA et al*., D.C. Circuit Court of Appeals, No.05-5015, (April 25, 2006) . On November 16, 2006, EPA issued national policy guidance stating the expectation that TMDLs will be set in terms of daily time steps (EPA, 2006). It is permissible to express a TMDL both in daily and non-daily terms. EPA believes that setting both daily and longer term TMDLs will assist in designing monitoring programs that effectively track progress in reducing pollutant loads and improving water quality. For example, grab sample monitoring results may be more easily compared to average daily allocations than to longer term allocations. The intent in setting both average daily and annual TMDLs and allocations is to meet TMDL regulatory requirements in a manner that is sensitive to how water quality control and monitoring programs are actually implemented. As bottom sediments in these water bodies contain substantial reservoirs of nitrogen and CBOD, there may be significant lag time between reductions of nitrogen and BOD loadings to these waters and full attainment of applicable water quality standards.

The TMDLs for each segment include a load allocation for “background” loads from the segment immediately upstream from the TMDL segment. It is important to note that the background load allocations representing allowable outflow from Tule Lake Refuge to Lower Klamath Refuge and from Lower Klamath Refuge to Straits Drain do not equal the TMDLs set for the upstream water bodies (the total allowable loads to Tule Lake Refuge and Lower Klamath Refuge). These quantities are not equivalent for three reasons. First, the water quality model indicates a substantial amount of nitrogen and CBOD discharged to Tule Lake and Lower

Klamath Refuges are consumed in these water bodies through biological processes, as described in Chapter 3. Second, the analysis projects that if the amount of nitrogen and CBOD discharged to these water bodies is reduced by 50% as projected in the TMDLs, the nitrogen and CBOD loads discharged from these waters will also be reduced by approximately 50%. Third, a significant percentage of water (with its associated DIN and CBOD loads) pumped from Tule Lake Refuge and Lower Klamath Refuge go to irrigation supply canals and not directly to the next "downstream" water segment. Taking into account each of these factors, the background load allocations for loading from Tule Lake Refuge to Lower Klamath Refuge and from Lower Klamath Refuge to Straits Drain were calculated as 50% of existing monitored nitrogen and CBOD loadings at the outlets of these water bodies.

It is also important to note that setting allocations for loading sources is different from setting TMDLs. Whereas TMDLs are set to achieve applicable water quality standards <u>in</u> the target water body, allocations are set for sources discharging <u>to</u> the target water body as necessary to meet the applicable water quality standards in the target TMDL water body. Setting allocations for a waterbody or other source that contributes pollutant loads to an impaired waterbody for which a TMDL is being developed does not mean the water or source that receives the allocations is itself impaired or (in the case of some source categories) is even required to meet water quality standards.

Table 6 (on the following page) identifies the TMDLs, load allocations, and wasteload allocations for each of the four segments.

6.2 MARGIN OF SAFETY ANALYSIS

The Clean Water Act requires the inclusion of a margin of safety in each TMDL to account for uncertainties concerning the relationship between pollutant loads and instream water quality and other uncertainties in the analysis. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL, or added as an explicit, separate component of the TMDL. This TMDL incorporates a margin of safety through use of conservative assumptions. First, the TMDL assumes year-round reductions in DIN and CBOD reductions are needed although the critical period in which water quality standards violations occur is during the summer months. Second, the W2 model calibration incorporates conservative rates for key water quality parameters. Third, the TMDL source analysis does not give "credit" for biological consumption of DIN and CBOD following discharge for purposes of estimating loading capacity.

Table 6. Lost River TMDLs and Allocations by Segment

SEGMENT	SOURCE	DISSOLVED INORGANIC NITROGEN (DIN) (metric tons/yr)	DISSOLVED INORGANIC NITROGEN (DIN) (average kg/day)	CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND (CBOD) (metric tons/yr)	CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND (CBOD) (avg. kg/day)
1	Lost River at Stateline Road (OR Border) Load Allocation	27.4	75.0	53.8	147.4
	Load Allocation for irrigation drainage loads to Lost River between Stateline Rd and Tule Lake (to Tulelake ID)	1.0	2.7	17.5	47.9
	Wasteload Allocation- CalTrans	0.1	0.3	0.2	0.5
TOTAL	**LOST RIVER (FROM BORDER TO TULE LAKE) TMDL**	28.5	78.1	71.5	195.8
2	Background load- from Lost River	28.5	78.1	71.5	204.3
	Load Allocation for irrigation drainage loads to Tule Lake (to Tule Lake ID)	34.9	95.7	249.8	684.4
	Wasteload Allocation- CalTrans	0.1	0.3	0.2	0.5
	Wasteload Allocation City of Tulelake WWTP	1.0	2.6	3.5	9.6
TOTAL	**TULE LAKE REFUGE TMDL**	64.5	176.7	325.0	898.8
3	Background load- from Tule Lake Refuge	19.5	53.4	246.0	674.0
	Load Allocation for irrigation drainage loads to Lower Klamath Refuge (to USFWS)	4.2	11.5	39.4	107.9
	Load Allocation- Ady Canal (to US Bureau of Reclamation)	4.2	11.5	39.4	107.9
	Wasteload Allocation- CalTrans	0.1	0.3	0.2	0.5
TOTAL	**LOWER KLAMATH REFUGE TMDL**	28.0	76.7	325.0	890.3
4	Background load from Lower Klamath Refuge	20	54.8	193.5	530.1
	Load Allocation for irrigation drainage loads to Straits Drain (to USBOR and USFWS)	1.4	3.8	21.0	57.5
TOTAL	**STRAITS DRAIN TMDL (LOWER KLAMATH REFUGE TO BORDER)**	21.4	58.6	214.5	587.6

CHAPTER 7: IMPLEMENTATION AND MONITORING RECOMMENDATIONS

EPA regulations do not require the development of implementation plans in TMDLs developed by EPA. The State of California includes implementation plans along with TMDLs in its Basin Plans. EPA recommends the following elements in an implementation plan in the 1992 "Guidance for Water Quality-Based Decisions: The TMDL Process." (EPA, 1992). The listed elements include:

- A description of the implementation actions and management measures,
- Legal or regulatory controls,
- A time line for implementing these measures,
- Time required to attain water quality standards,
- Monitoring plan and milestones for attaining water quality standards, and
- Adaptive Management

EPA is including implementation recommendations in this document to assist local stakeholders in targeting actions to address suspected causes of water quality impairment in the Lost River system. These implementation recommendations are not part of the TMDLs in Chapter 6 that are being established by EPA pursuant to Clean Water Act Section 303(d) and federal regulations at 40 CFR 130.7. The implementation recommendations are strictly advisory and are not required to be implemented under federal law. We encourage the State and local stakeholders to consider these implementation recommendations to guide future water quality protection efforts in the basin.

7.1 RECOMMENDED IMPLEMENTATION ACTIONS

Since much of the data utilized for the development of the Lost River TMDL was from 1999, actions taken since 1999 may have already reduced nutrient and BOD loads. Thus, many of the recommended activities below should be evaluated to determine if current actions have already resulted in sufficient pollutant reductions and associated water quality improvements. Furthermore, at the time California considers adoption of these TMDLs and implementation measures developed by the State through the Basin Planning process, EPA recommends that the State evaluate whether dischargers have implemented effective pollutant controls including, but not limited to, those recommended below, in determining appropriate implementation strategies and the relative degree of reliance on voluntary or regulatory control approaches.

Below we describe a few recommended general strategies which are intended to promote activities that will improve water quality over time, with the ultimate goal of achieving TMDL load allocations and meeting water quality standards in the Lower Lost River. Specific recommended actions are included in Table 7. The implementation actions are also designed to encourage and build upon ongoing, proactive restoration and enhancement efforts. The actions are organized by topic and appropriate party.

Table 7. Recommended Implementation Actions

Topic	Appropriate Parties	Recommended Actions to Address Nutrient Loadings	Outcomes
(1) Nutrient and agricultural land management	Growers/ Individual Irrigators	Develop a nutrient and residue management plan to reduce nutrients and achieve TMDL load allocations. A nutrient and residue management plan is a plan that details how growers or a group of growers will manage the amount, source, placement, form and timing of the application of nutrients and soil amendments. A nutrient management plan will assist growers to manage commercial fertilizer and animal manure input costs. It will also help to improve surface water quality. The purposes of a nutrient management plan are: • To adequately supply nutrients for plant production; • To properly utilize manure or organic by-products as a plant nutrient source; • To minimize agricultural nonpoint source pollution of surface and ground water resources; and • To maintain or improve the physical, chemical and biological condition of soil.	Develop nutrient and residue management plans. Collaborate with partners to establish and implement bi-annual trend monitoring plans.
	Tulelake and Klamath Irrigation Districts Natural Resource Conservation Service (NRCS) and Resource Conservation Districts	• Provide guidance and support for development and implementation of nutrient and residue management plans. • Provide assistance and input to Bureau of Reclamation and/or other partners to establish and implement coordinated bi-annual trend monitoring plans.	
(2) Establish working group to refine implementation recommendations	Klamath Water Users Association UC Intermountain Research and Extension Center	• Facilitate development of a working group to refine implementation recommendations that will result in the achievement of the TMDL load allocations. • Promote collaboration with interested partners to establish a Lower Lost River-specific TMDL implementation plan with roles and responsibilities building on the existing recommendations in this document and on the results of the bi-annual trend monitoring.	Facilitate establishment of a working group.
(3) Reduce/revise on-farm fertilizer application and reduce tailwater return flows	Growers/ Individual Irrigators	• In conjunction with developing nutrient and residue management plans, evaluate the feasibility of switching to crops/varieties with reduced fertilizer needs. Appropriate crop nutrition management decisions might include: • Conduct yearly soil sampling to determine plant nutrient needs; • Credit other sources that contribute nitrogen and phosphorous to the soil; • Apply the appropriate form of nitrogen fertilizer to reduce	Investigate and document results of feasibility for reduced fertilizer needs. Identify resources for assess tailwater recovery opportunities.

Table 7. Recommended Implementation Actions			
Topic	**Appropriate Parties**	**Recommended Actions to Address Nutrient Loadings**	**Outcomes**
		leaching from and to avoid over-fertilization of target fields; - Time the applications to coincide with maximum crop uptake; - Calibrate equipment at least annually to ensure that the recommended amount of fertilizer is spread; - Correct fertilizer placement in the root zone to enhance plant nutrient uptake and minimize losses. Subsurface application should be used instead of a surface broadcast fertilizer; - Document and maintain records of fertilizer use to determine if reductions in application are enhancing water quality. Collaborate with Bureau of Reclamation or other parties to provide access for monitoring efforts. - Manage irrigation water efficiency by using delivery systems such as lined ditches and gated pipes, as well as reuse systems such as field drainage recovery ponds, that efficiently capture sediment and nutrients. - Conduct assessments of tailwater return flows to identify and promote opportunities to minimize and reuse where feasible. - Manage tailwater return flows so that entrained constituents, such as fertilizers, are not discharged to nearby watercourses. This could include modifications to irrigation systems that reuse tailwater by conducting off-stream retention basins, active pumping and/or passive tailwater recapture/ redistribution systems.	
	Tulelake Irrigation District	- Assist growers with developing mechanisms to support the reduction of fertilizer application and tailwater return flows.	
	UC Intermountain Research and Extension Center NRCS and Resource Conservation Districts	- Provide planning support, training and technical support to growers to assist with matching fertilizer applications to crop needs. - Offer training and education on innovative techniques that can minimize the use of fertilizers, while maintaining or increasing yields. - Assist with the development and implementation of on-farm management plans. - Assist with developing recommendations for improved tailwater return flow activities. - Provide guidance to Bureau of Reclamation and/or other parties to establish bi-annual monitoring to determine if the reduction in fertilizer use results in decreased nutrient loads. - Identify resources and establish study opportunities for increased	Development and facilitate the implementation of water conservation plans that will increase water quality benefits. Document NRCS water conservation activities already underway.

Table 7. Recommended Implementation Actions

Topic	Appropriate Parties	Recommended Actions to Address Nutrient Loadings	Outcomes
		recycling of tailwater onto crop lands.	
(4) Drip irrigation, sprinkler irrigation alternatives to flood irrigation and other water conservation practices to reduce nutrient loads	Growers / Individual Irrigators	• Identify resources to modify irrigation systems to reduce nutrient leaching and concentrations in the collection and tile drains and to combat the increase in energy rates. • Research and consider implementation of drip and sprinkler irrigation systems, which will reduce the amount of water consumed per acre. Initial capital costs for installation of irrigation systems (including pumps, piping, delivery devices, soil moisture monitoring devices and possibly automated computer controls) can be relatively high, but can be offset by NRCS EQUIP funds. With several million in EQIP funds spent in the Klamath Basin, on irrigation efficiencies, additional water quality benefits may have been achieved. The following are additional methods that can be used to conserve water that could have ancillary benefits of achieving load allocations: • If pre-irrigated, farmers could grow a cereal crop even if water deliveries are cut off during drought years. Juniper control on rangelands may yield additional water. • During years that alfalfa fields are rotated to grain, winter flooding or pre-season irrigation could be used to reduce water demand. • On hay and croplands, upgrading existing irrigation systems and improving irrigation water management will decrease water demand. Subsurface drainage could be added before re-establishing alfalfa stands, permitting better control of water table and soil moisture levels. • Implement mechanisms to measure the effect of water conservation efforts on nutrient load allocations.	Develop and implement water conservation plans and identify opportunities for recycling.
	NRCS and Resource Conservation Districts	• Document water conservations activities already taken or underway and identify resources to determine if the conservation activities have lead to improved water quality. • Evaluate water quality benefits of water conservation and distribution of equipment and funds installed post 1999. • Implement before and after monitoring of tile drains to ensure best management practice efficiency. • Continued trend monitoring to illustrate improvements and the effectiveness of sprinkler irrigation.	Document conservation activities already underway. Implement conservation outreach.

Table 7. Recommended Implementation Actions

Topic	Appropriate Parties	Recommended Actions to Address Nutrient Loadings	Outcomes
		• Provide education and planning support on effective water conservation opportunities.	
(5) Improve Irrigation uniformity	Tulelake Irrigation District UC Intermountain Research and Extension Center	• Assist with developing improvements in the manner of flood irrigation and scheduling to ensure better matching of amounts of water delivered to crop needs as a way to reduce nutrient loads. • Pump testing is one way to increase energy efficiency of irrigation systems by replacing nozzles, which will assist with uniformity. • Provide education, planning and support to improve irrigation uniformity.	Collaborate with operators and resource partners to modify schedules and water usage as necessary.
(6) Aquatic plant removal in canals and open-ditch management	Growers / Individual Irrigators	• Establish methods to reduce the amount of aquatic plant growth in canals. ◦ Harvesting is the backbone of aquatic plant management because it efficiently manages plants in large areas, removes some nutrients and reduces the need for chemical herbicides. However, the limitation to machine or hand harvesting is that the equipment is expensive and harvesters do not remove roots so regrowth and reharvesting is often necessary, sometimes within the same season. • Focus efforts to reduce or prevent fertilizers and other chemicals from leaving fields to maximize their availability for plant growth and reduce adverse surface water quality impacts. • Implement other approaches such as vegetation and/or management of the ditch geometry.	Investigate feasibility and benefits of aquatic plant removal.
	Tulelake Irrigation District	Evaluate efficiency of installation of the conveyor belt systems to remove excess aquatic plant growth and share lessons learned.	Transfer technology and lessons learned through conveyor belt systems.
	NRCS and Resource Conservation Districts	• Conduct research and educational outreach on practices and resources available for aquatic plant removal, open ditch management and algae removal/management. • Identify resources, determine the effectiveness and establish a plan for open-ditch management.	Facilitate and provide support for aquatic plant removal and open-ditch management strategies.

Table 7. Recommended Implementation Actions			
Topic	**Appropriate Parties**	**Recommended Actions to Address Nutrient Loadings**	**Outcomes**
	Bureau of Reclamation	• Provide assistance with aquatic plant removal. • Assist growers to determine if aquatic plant removal will help to meet TMDL load allocations and develop bi-annual monitoring to determine if the aquatic plant removal has decreased nutrient loads.	Establish bi-annual monitoring to determine if the algae removal has assisted in achieving TMDL load allocations.
(7) Enhanced nutrient removal in the Tule Lake and Lower Klamath National Wildlife Refuge wetland areas <u>and</u> Walking Wetlands (rotating a flooded wetland cycle, on a one to four year basis)	US Fish and Wildlife Service	• Investigate opportunities to expand the Walking Wetlands program beyond the existing 3,500 acres in the National Wildlife Refuge (NWR) areas and private lands and determine if the Lower Klamath NWR could be utilized for water quality treatment. • Document how the two National Wildlife Refuge areas are managed, for example, water temperatures, depth, etc. and investigate ability to modify wetland structure and/or water flow. • Study possibilities to configure water delivery and drainage system on the Lower Klamath NWR so that existing wetlands satisfy wildlife habitat requirements and are optimally used for water quality treatment. • Increase coop farming in the Tule Lake NWR, which has already expanded organic farming and decreasing nutrient loads. In the coop farm, ¼ of the crop is utilized for birds and harvesting and ¾ limited to small grains. • Explore ways to use “walking wetlands” as a method to reduce nutrients loads, provide wildlife habitat, and improve sustainability of farming in the Tulelake NWR and determine whether such techniques have applicability on private lands. • Investigate and identify ways to use existing and future wetlands to provide wildlife habitat and improve water quality with the goal of achieving load allocations, as part of the development of the larger Comprehensive Conservation Plan for the Klamath Basin • Seek opportunities working with voluntary partners to expand wetland acreage as a means to improve water quality in the Lower Lost River basin • Continue to evaluate potential for wetlands management activities to improve water quality and pursue activities that will promote denitrification. For example, monitor results of wetland enhancement projects within Sump 1B in Tule Lake NWR to determine impact on nutrient loads. • Promote fertilizer management plans on leased lands to achieve TMDL load allocations.	Evaluate waterfowl discharge and determine applicability of National Wildlife Refuge areas for water quality treatment. Increase Walking Wetlands acreage. Explore opportunities for monitoring water quality treatment in the Lower Klamath Refuge.

Table 7. Recommended Implementation Actions			
Topic	**Appropriate Parties**	**Recommended Actions to Address Nutrient Loadings**	**Outcomes**
		• Explore opportunities to recycle water (and nutrients) within the Refuge areas.	
	Tulelake Irrigation District UC Intermountain Research and Extension Center	Evaluate and determine what changes in configurations, if any, could be made to enhance denitrification in the Tule Lake National Wildlife Refuge.	
(8) Management of Agricultural Practices on leased lands	US Fish and Wildlife Service	Encourage use of BMPs and development of generic nutrient and residue management plans and establish language in leases to achieve TMDL load allocations on an experimental or demonstration basis on leased lands, similar to the pesticide residue analysis already underway in the NWR.	Develop revised experimental lease language.
(9) Monitoring	Bureau of Reclamation and other interested parties as identified	• Establish basin-wide monitoring program with trend monitoring stations to assist in determining water quality improvements and progress towards achieving load allocations. • Work with growers, individual irrigators and other interested parties to gain permission for access, as needed to collect monitoring data. Monitoring may involve implementation, upslope effectiveness, photo documentation, in-stream and near stream effectiveness and compliance and trend monitoring. • Issue annual monitoring data reports. • Collaborate with partners to identify monitoring resources/funding and establish efficient methods to achieve TMDL load allocations.	Develop monitoring plan and implement bi-annual trend monitoring.
(10) Water Treatment and Recycling	Bureau of Reclamation	• Evaluate possibilities of water quality benefits of water recycling through Klamath Straits Drain and other recycling efforts in concert with other actions that may be considered as part of the Klamath mainstem TMDLs and/or the Oregon Lost River TMDLs. • Study methods to treat or recycle agricultural return flows from the Klamath Project service area. • Investigate whether more recycling will assist in achieving TMDL load allocations.	Research feasibility of irrigation water recycling and/or treatment.
(11) Memorandum of Understanding	US Environmental Protection Agency Bureau of Reclamation US Fish and Wildlife	Establish a memorandum of understanding between the relevant federal agencies to outline appropriate roles and responsibilities, such as joint funding for monitoring, to achieve TMDL load allocations.	Establish MOU.

Table 7. Recommended Implementation Actions			
Topic	**Appropriate Parties**	**Recommended Actions to Address Nutrient Loadings**	**Outcomes**
	Service		
(12) Agricultural Waivers, WDR and/or prohibitions for agricultural operations	North Coast Regional Water Quality Control Board (NCRWQCB)	• The statewide non-point source policy states that all current and proposed discharges must be regulated under waste discharge requirements or waivers. In 1999 the State was tasked with reviewing and either renewing Irrigated Agriculture runoff waivers or replacing them with waste discharge requirements. The amendment requires the State's enforcement of conditions in waivers and the readoption of waivers every five years. Then in 2003 the State Board was tasked with establishing fees for waivers. The NCRWQCB has no immediate plans to adopt generic agricultural waivers, but may do so to implement TMDLs. • Utilize recommendations in this implementation plan as a framework for specific waivers when implementing waiver provisions. • Assess implementation progress when establishing a framework for the agricultural waivers. • Collaborate with other state and federal partners to develop an inclusive monitoring plan to achieve TMDL load allocations and ensure monitoring plans for the Lower Lost River discharges are established and implemented. • Publicize grant funding opportunities for implementation activities.	Collaborate with other state and federal partners to develop an inclusive monitoring plan to achieve TMDL load allocations. Ensure monitoring plans for the Lower Lost River discharges are established and implemented.

7.2 MONITORING

It is recommended that the U.S. Bureau of Reclamation work with partners to develop a trend monitoring program for the Lower Lost River basin. The first step would be to develop a monitoring plan that should include a description of monitoring objectives, parameters to monitor, sampling procedures and techniques, locations of monitoring stations, frequency and duration, quality control and quality assurance protocols, benchmark conditions where available, measurable milestones and specific timelines for monitoring, data analysis and reporting. Another important component of a monitoring program is regular reporting and analysis of results. Monitoring trends in water quality is important to: track TMDL implementation, monitor progress towards improving water quality, and provide feedback for modifying implementation actions as necessary to ensure that actions are effective and water quality improvements are being accomplished.

7.3 ADAPTIVE MANAGEMENT

Through the methods outlined above, EPA has proposed a provisional schedule to ensure measurable improvements in water quality are accomplished in the Lower Lost River by 2012, with the overall goal of attaining needed load allocations and targets by 2018 (see Table 8). As EPA recognized in 1995 in establishing the Great Lakes Water Quality Guidance, "Determining the reasonable period of time in which water quality standards will be met is a case-by-case specific determination considering a number of factors including, but not limited to: behavior and ubiquity of pollutants of concern; type of remediation activities necessary; available regulatory and non-regulatory controls; and individual State or Tribal requirements for attainment of water quality standards." [Appendix F to 40 CFR part 132 (60 Federal Register p. 15416, March 23, 1995)]. EPA acknowledges that the Lower Lost River system is unique, fragile and known to be highly dynamic where recovery from nutrient loads and inputs may take time. EPA recognizes this by targeting final achievement of TMDL load allocations over a reasonable timeframe, while also identifying interim targets. EPA also welcomes appropriate parties' participation in tracking implementation efforts, schedules and report on progress to ensure water quality improvements are attained. That said, EPA also believes that, even though there is uncertainty regarding how long this river system may take to fully recover and how much past practices may be influencing current conditions, given the current conditions of the river there is a need to speed up recovery to the extent practicable.

EPA's adaptive management approach for implementing the TMDL and including interim targets will also provide appropriate check points to assure that actions are resulting in load reductions and that water quality conditions in the basin are improving. The goal is to establish a framework where actions for improving water quality will be carried out, monitoring will occur to determine the effectiveness of these actions, and a periodic analysis of the collective impact of the actions and review of TMDL goals will occur, which will be informed by any additional or improved information that may become available. EPA's Guidance also recommends that the schedule include a time frame within which water quality standards are expected to be met. The collected information (including linkages to Oregon TMDLs) would then be used to determine whether the TMDL load allocations need to be revised.

Table 8. Recommended Implementation Actions Timeline

Table 8. Recommended Implementation Actions Timeline	
Appropriate Parties	**Year 1-2: 2008-2009**
US Environmental Protection Agency and Regional Water Quality Control Board	• Consider non-regulatory measures including development of memorandum of understanding with implementing organizations and possible incentives to control waste discharges and conduct watershed restoration activities. • Participate in KWUA working group, as appropriate, to refine implementation plan.
Klamath Water Users Association	• Facilitate development of a working group to refine implementation recommendations contained in this document. • Produce a plan with clear milestones and outcomes.
Growers / Individual Irrigators NRCS and Resource Conservation Districts	• Collaborate to develop nutrient and residue management plans to achieve TMDL load allocations.
Tulelake Irrigation District	• Transfer technology and lessons learned through conveyor belt system for aquatic plant removal.
Growers / Individual Irrigators NRCS and Resource Conservation Districts UC Intermountain Research and Extension Center	• Investigate and document results of feasibility for reduced fertilizer needs. • Identify resources and establish study opportunities for tailwater recovery. • Develop and implement water conservation plans that will increase water quality benefits. • Document NRCS water conservation activities already underway. • Implement water conservation outreach.
Bureau of Reclamation	• Develop trend monitoring plan with input from partners, which considers filling gaps in current data and for ensuring progress with implementation measures. • Identify resources for monitoring with assistance from various partners. • Implement monitoring in areas where water quality improvements are expected due to post 2001 water conservation activities. • Investigate feasibility of treatment and/or recycling of irrigation return flows from Project Area.
US Fish and Wildlife Service	• Identify actions to improve water quality as part of the development of the Refuge Comprehensive Conservation Plan
US Environmental Protection Agency, US Fish and Wildlife Service, Bureau of Reclamation, Klamath Water Users Association	• Establish a Memoranda of Understanding to implement TMDL actions.
	Years 3-5: 2010-2012
Klamath Water Users Association	Collaborate with interested partners and establish a Lower Lost River-specific TMDL implementation plan with roles and responsibilities building on the existing recommendations in this document

All appropriate parties	Start implementation actions.
Growers / Individual Irrigators	Establish and implement improved irrigation systems.
Growers / Individual Irrigators UC Intermountain Research and Extension Center Natural Resource Conservations Districts	Investigate studying impacts from return flows and appropriate measures to enhance water quality of return flows.
Tulelake Irrigation District UC Intermountain Research and Extension Center	Collaborate with operators and resource partners to modify schedules and water usage as necessary.
Bureau of Reclamation	• Prepare a bi-annual monitoring report to determine if aquatic plant removal and other recommended actions have assisted in achieving TMDL load allocations. • Pursue funding for implementation feasible treatment or recycling options.
US Fish and Wildlife Service	• Evaluate waterfowl discharge and determine applicability of National Wildlife Refuge areas for water quality treatment. • Increase walking wetlands acreage. • Explore opportunities for water quality treatment in the Lower Klamath Refuge.
	Years 6-8: 2013-2015
Bureau of Reclamation, US Fish and Wildlife Service, Klamath Water Users Association and All appropriate parties	• Report on implementation actions and monitoring results. • Evaluate and refine implementation actions. • Evaluate and refine timeframes for achieving load allocations based on effectiveness of implementation actions, feasibility, and new scientific information.
	Years 9-11: 2016-2018
Bureau of Reclamation, US Fish and Wildlife Service, Klamath Water Users Association and All appropriate parties	Document achievement of TMDL load allocations through monitoring results (note: this is an initial estimate of time needed to meet load allocations and could be changed based on evaluations conducted in years 6-8.

7.4 POTENTIAL FUNDING SOURCES

This section discusses potential federal and state sources of funding that may be available to assist in implementation of control actions.

A. Natural Resource Conservation Service - the **Environmental Quality Incentives Program (EQIP)** was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. For more information please visit: http://www.nrcs.usda.gov/programs/eqip/

B. State Water Resources Control Board/Regional Water Quality Control Board - The Water Boards provide funding from State Bonds and the federal Clean Water Act (CWA) to address nonpoint source water quality problems. Some of these funds have been specifically focused on addressing concerns related to irrigated agricultural lands and supporting related water quality monitoring. Most funds give priority consideration to TMDL water bodies. The funds are available to eligible applicants (e.g., RCDs, local government, non-profit organizations, etc.) to implement projects that reduce the discharge of pollutants and to address California’s need for water quality monitoring, which will further assist to define and identify the source of water quality problems. The funding amounts vary from year to year. The funding is typically available yearly; however the next Request for Proposals (RFP) is not likely to be released until Fall 2007. EPA encourages applicants for CWA Section 319 funds to work together with Farm Bill funding. In addition, Section 319 funds must be used for projects implementing TMDLs and watershed plans which include:

(1) Explicit short- and long-term goals, objectives and strategies to protect surface and ground water;
(2) Strong working partnerships and collaboration with appropriate State, interstate, Tribal, regional, and local entities (including conservation districts), private sector groups, citizens groups, and Federal agencies;
(3) A balanced approach that emphasizes nonpoint source solutions and on the ground management of the watershed where waters are impaired or threatened;
(4) Abate known water quality impairments resulting from nonpoint source pollution and prevent significant threats to water quality from present and future activities;
(5) An identification of waters and watersheds impaired or threatened by nonpoint source pollution and a process to progressively address these waters;
(6) Review, upgrade and implement program components required by Section 319 of the Clean Water Act and establish flexible, targeted, iterative approaches to achieve and maintain beneficial uses of water as expeditiously as practicable;
(7) An identification of objectives which are not managed consistently with State program objectives;
(8) Efficient and effective management and implementation of nonpoint source programs in the watershed, including necessary financial management; and
(9) A feed back loop whereby there are reviews, evaluations and revisions to nonpoint source assessments and management programs at least every five years. For more information: http://www.swrcb.ca.gov/funding/index.html

C. USEPA's Wetland Program Development Cooperative Agreements and Grants are for States, Tribes and local governments to aid in developing wetland protection programs. The program requires a 25% nonfederal match and funds can be used to build and refine any element of a comprehensive wetland program, with priority given to developing a comprehensive monitoring and assessment program, improving the effectiveness of compensatory mitigation and refining the protection of vulnerable wetlands and aquatic resources. http://www.epa.gov/owow/wetlands/grantguidelines/

D. USEPA's Watershed and Water Quality Modeling Technical Support Center provides assistance to EPA regions, states, local governments and their contractors to provide access to technically defensible tools and approaches that can be used in the development of TMDL, waste load allocations and watershed protection plans. www.epa.gov/athenswwqtse/index.html

E. USEPA provides funding through the establishment of a **State Revolving Fund (SRF) loan program**. The program is funded by federal grants, State funds, and Revenue Bonds. The purpose of the SRF loan program is to implement the CWA and various State laws by providing financial assistance for the construction of facilities or implementation of measures necessary to address water quality problems and to prevent pollution of the waters of the State. The SRF Loan Program provides low-interest loan funding for construction of publicly-owned wastewater treatment facilities, local sewers, sewer interceptors, water reclamation facilities, as well as, expanded use projects such as implementation of nonpoint source (NPS) projects or programs, development and implementation of estuary Comprehensive Conservation and Management Plans, and storm water treatment. For more information: http://www.swrcb.ca.gov/funding/srf.html

F. The Volunteer Monitoring Program helps volunteer water monitors build awareness of pollution problems and increase the amount of water quality information available to decision-makers at all levels of government. http://yosemite.epa.gov/water/volmon.nsf

G. Bureau of Reclamation's Water Resources Research Laboratory performs research to improve BOR efforts including fish protection/screening, fish passage, reservoir release water quality, river restoration and wetlands. www.usbr.gov/pmts/hydraulics_lab

H. USGS National Water Information System (NWIS) provides water data, including real time water data, surface water flow measurements and water quality measurements. USGS is available to support development of TMDLs. http://water.usgs.gov/pubs/fs/FS-130-01, http://waterdata.usgs.gov/nwis, http://water.usgs.gov/nawqa

I. US Fish and Wildlife Services' Partners for Fish and Wildlife provides technical and financial assistance for habitat restoration projects on lands not owned by a state or federal government to provide watershed management, conservation easements and river restoration in cooperation with voluntary landowners. USFWS develops a cost-sharing agreement with the partner typically 50% is required and funding provided after completion of the project. Technical assistance is also available. www.fws.gov/partners.

CHAPTER 8: PUBLIC PARTICIPATION

EPA is committed to providing opportunities for interested stakeholders to participate in TMDL development for the Lower Lost River. EPA defines “stakeholders” as community members, other agencies, tribes, environmental groups, community and business organizations, landowners and others with interest in the watershed. Stakeholder involvement is important to this project in order to ensure pertinent information about the Lost River is shared and to ensure that interested stakeholders have an opportunity to identify, address and receive information about Lower Lost River projects as related to the TMDL implementation. Public participation will continue to involve the following elements:

- Identification of stakeholders and list of contacts,
- Stakeholder informational meetings,
- Targeted outreach to particular stakeholders, and
- Development of outreach documents, including fact sheets

To date, EPA, in conjunction with our state water quality partners, has held approximately six outreach and scoping meetings in the Klamath Basin on February 25-26, 2004, March 2 2004 and June 12-15, 2006 to provide an opportunity for various stakeholders to understand and respond to EPA’s role in the TMDL development and recommendations for the Lower Lost River Implementation Plan. EPA plans to host a formal public review in Spring 2006. As part of the public participation process, EPA has and will continue to offer: briefings to various groups, prepare and distribute an executive summary of the technical TMDL and the recommendations for implementation, and schedule targeted outreach meetings with particular stakeholder groups such as the Tulelake Irrigation District, Resource Conservations Districts, academia and individuals farmers.

Stakeholders’ Roles and Responsibilities

- EPA Region 9 is working with EPA Region 10, Oregon Department of Environmental Quality (DEQ) and the North Coast Regional Water Quality Control Board (NCRWQCB) to develop TMDLs for the Lost River (and the related Klamath River) and recommendations for the implementation plan. EPA will host a variety of meetings to ensure interested stakeholders have an opportunity to participate in the process. EPA will monitor the progress of the TMDL implementation actions and work with the NCRWQCB to achieve compliance.
- North Coast Regional Water Quality Control Board (NCRWQCB) cannot meet the court ordered schedule to complete the TMDL for the Lower Lost River. Nevertheless, there are several mechanisms available to the State to implement the actions necessary to meet a TMDL. These mechanisms include: non-regulatory actions, such as third party agreements and self-determined pollutant control; a Memorandum of Understanding to describe the specific regulatory actions to be taken; and regulatory actions such as a permit, waiver, or an enforcement order.
- Oregon DEQ will collaborate with the NCRWQCB and EPA to ensure that Lost River waters entering California will meet the specified objectives of the TMDL to meet the load allocations of 50% reductions from 1999 baseline conditions. Oregon DEQ will develop a TMDL for the Lost River in Oregon concurrently with the TMDLs for Klamath River to be completed by approximately 2009.

- Tulelake Irrigation District was established in 1956 when homesteaders organized under California law to manage parts of the Klamath Project that service their farms. Today, the district provides water through 37 pumping plants to over 63,000 acres and approximately 600 growers.
- Klamath Irrigation District is tasked with promoting the protection and use of water rights and the wise stewardship of water resources in Oregon. The District will work with Oregon DEQ and the NCRWQCB to ensure that water passing the California border meets the specified objectives of the TMDL.
- US Bureau of Reclamation's (USBOR) Klamath Basin Area Office employs 30 staff who assists in the management of the Klamath Project, a Federal storage project built in the early 1900's to provide irrigation for about 240,000 acres. More than 1,400 miles of canals and drains provide service to water users in the Klamath and Lost River watersheds. In addition, four national wildlife refuges also receive water and are adjacent to or within the service area. Project facilities operated by the USBOR include Ady Canal and Klamath Straits Drain.
- US Fish and Wildlife Service (USFWS) owns and operates the Tule Lake and Lower Klamath National Wildlife Refuges. USFWS manages these refuges to enhance wildlife and to support the local agricultural economy that is dependent upon Refuge lands. USFWS and USBOR have signed an agreement under which they coordinate agricultural and water management programs.

The following organizations are available to assist growers, individual irrigators, landowners and operators who are responsible for recommended implementation actions on fields to develop and devise plans for achievement.

- Klamath Water Users Association (KWUA) represents private rural and suburban irrigation districts and ditch companies within the Klamath Project, along with private irrigation interests outside the Project in both Oregon and California in the Upper Klamath Basin. KWUA is governed by an eleven-person board of directors elected from supporting irrigation districts, private irrigation interests, and the business community and represents over 5,000 water users on 1,400 family farms.
- Natural Resource Conservation Service (NRCS) is providing technical assistance under an adaptive management strategy through various Farm Bill programs. NRCS technical standards, quality criteria, and planning policies are designed to ensure effective on-farm practices and to provide the necessary resources to address agricultural concerns. Rapid subbasin assessments provide information that will assist in prioritizing the application of conservation practices in the Basin recognizing the need to evaluate cumulative impacts beyond the farm boundaries and to determine the extent that their conservation activities effectively address basin-wide resource issues such as water quality. NRCS recognized the cumulative impact analysis needs to be done in partnership with organizations and groups in the basin.
- Resource Conservation Districts can assist growers / individual irrigators to develop and implement management practices that minimize, control and prevent discharges of nutrients into the Lower Lost River and assist to develop and implement monitoring plans to evaluate and document implementation and effectiveness of actions executed.
- UC Cooperative Extension farm advisor Harry Carlson, based at the UC Tulelake Research and Extension Center located in the Klamath Basin just four miles south of the Oregon border, has been a vital local link to UC's scientific resources and playing an expanded role in trying to establish a basis for solving some of the environmental issues in the area.

- Environmental Organizations: Pacific Coast Fisherman's Federation of America, Environmental Protection Information Center and Endangered Species Groups

EPA is providing a formal comment period for the public to review the draft Lost River TMDLs. EPA has provided public notice of the draft TMDLs by placing a notice of availability in the *Klamath Falls Herald and News*, as well as making the Notice and Public Draft TMDLs available on EPA Region 9's website. The public notice has also be mailed or emailed to additional interested parties. EPA will consider all written comments received during the comment period, make revisions as warranted based upon those comments, and prepare a written responsiveness summary demonstrating how each public comment was considered in the final TMDL decision.

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