CHAPTER 10. WATER QUALITY

INTRODUCTION

The purpose of this water quality assessment is to complete a screening-level analysis of water quality. It will identify known areas where water quality is impaired by comparing select water quality measurements to evaluation criteria. This analysis uses existing data obtained from various sources. It does not include statistical evaluation of seasonal fluctuations or trends through time, nor does it evaluate specific sources of pollution through upstream-downstream comparisons.

This analysis includes three steps: (1) identifies beneficial uses for aquatic resources that are sensitive to adverse changes in water quality; (2) establishes the evaluation criteria; and (3) examines the existing water quality data compared to evaluation criteria. Conclusions are then made about the presence of known water quality problems in the watershed and whether or not additional studies are necessary.

Although there are many parameters that indicate the water quality of a stream, this assessment focuses on seven that are most often measured and that have a direct effect on aquatic organisms: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity and chemical contaminants. Evaluation criteria are determined by regulatory entities based on values of these parameters that are generally protective of aquatic life. Some other aspects of water quality, such as fine sediment load, are dealt with in other sections.

Protection of water quality in Oregon is based on water quality standards developed by the Oregon Department of Environmental Quality (ODEQ). Standards, which are benchmarks that indicate whether a pollutant is present, are set to protect designated beneficial uses. Beneficial uses are uses of water necessary for the survival or well-being of man, plants and wildlife. Beneficial uses can include fishing, aquaculture, agriculture, navigation and habitat. When a water body meets the standards, the beneficial uses of the water body are not impacted. By ODEQ definition, a water quality standard is composed of: (1) designated uses of a water body that set the water quality goals of a water body (e.g., resident fish and aquatic life, water contact recreation); (2) water quality criteria that define the minimum conditions necessary to achieve the designated use—these can be numeric, (e.g., a specific temperature value) or narrative (stating, for example, that the water should not have oil slicks, or objectionable color or odor); and (3) antidegradation policy that prevents existing water quality from degrading unless specific circumstances apply. The antidegradation policy complements the use of water quality criteria. While criteria provide the absolute minimum values or conditions that must be met in order to protect designated uses, the antidegradation policy offers protection to existing water quality, including instances where that water quality equals or is better than the criteria.

BENEFICIAL USES

The Clean Water Act requires that water quality standards be set to protect the beneficial uses that are present in each water body. Beneficial uses for the purpose of water quality regulation are determined by ODEQ for each of 19 river basins in Oregon. The Lower Sprague-Lower Williamson subbasin is included in the Upper Klamath Basin. Beneficial uses for the Upper Klamath Basin are given in Oregon Revised Statute (ORS) 340-41-0180, and include:

Private domestic water supply
Industrial water supply
Irrigation
Livestock watering
Fish and aquatic life
Wildlife and hunting
Fishing
Boating
Water contact recreation
Aesthetic quality
Hydro power

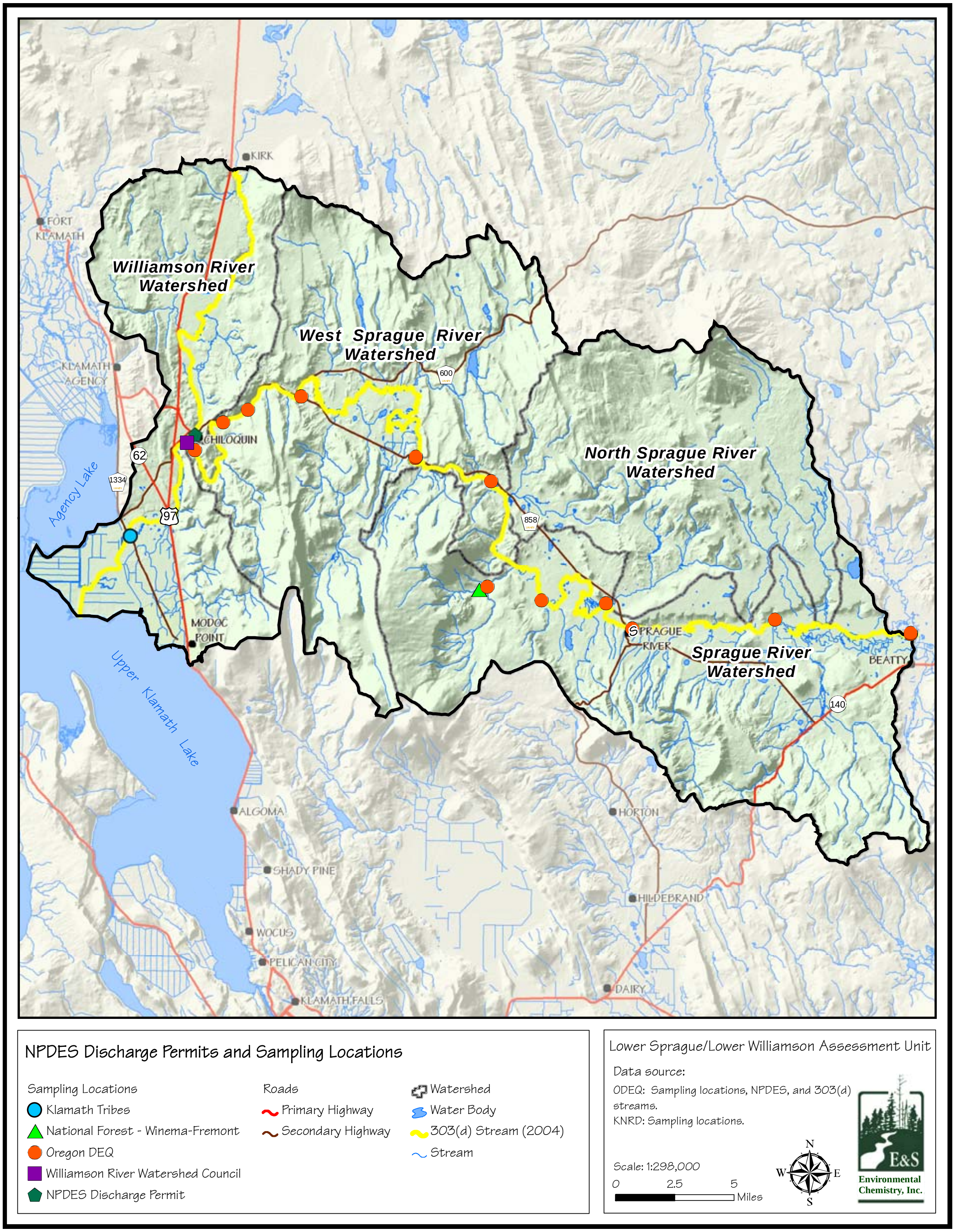
It is important to note that the main-stem streams within the assessment area are considered to have access by floating the river. However, the public cannot stop on the banks of the river without permission from the adjacent landowner. The landowner owns the ground under the river to the center of the river. Anchoring a boat or standing on the bank constitutes trespassing.

The water quality requirements to meet the determined beneficial uses differ. For example, the requirements for domestic water supply may be more stringent in some aspects than those for livestock watering. Frequently, the most sensitive beneficial use is considered when making decisions regarding designation of a water body as water quality limited. Federal law requires that the most sensitive beneficial use be protected. The state implements this requirement through the state water quality standards. The underlying assumption is that if the water body meets the criteria for the most sensitive use, it will meet the criteria for other uses as well. For most of the Lower Sprague-Lower Williamson subbasin, the most sensitive beneficial use is fish and aquatic life.

POLLUTANT SOURCES

Point Sources

The Clean Water Act regulates discharge of waste to surface water. In order to discharge any waste, a facility must first obtain a permit from the State. In Oregon, ODEQ issues two primary types of discharge permit. Dischargers with Water Pollution Control Facility (WPCF) permits are not allowed to discharge to a water body. Industries, municipal wastewater treatment facilities, fish hatcheries and similar facilities typically have National Pollutant Discharge Elimination System (NPDES) permits. Most WPCF permits are issued for on-site sewage disposal systems. Holders of NPDES permits are allowed to discharge wastes to waters of the state, directly or indirectly, but their discharge must meet certain quality standards, as specified in their permits. There is one NPDES permit for the City of Chiloquin (see Map 10-1).



Map 10-1 Water quality limited streams and sites sampled for water quality by ODEQ, USFS, Klamath Tribes Natural Resources Department (KNRD), and Klamath Tribes in the Lower Sprague-Lower Williamson subbasin
(Data Sources: ODEQ 2007a, KNRD 2006)

Nonpoint Sources

The largest current source of pollutants to Oregon's waters is not point sources, such as factories and sewage treatment plants, but rather comes from surface water runoff, often called "nonpoint source" pollution (ODEQ 2002, ODEQ 2006). Rainwater, snowmelt and irrigation water flowing over roofs, driveways, streets, lawns, agricultural lands, construction sites and logging operations carry more pollution, such as nutrients, bacteria and suspended solids, than discharges from industry (ODEQ 2002, ODEQ 2006).

Land use can have a strong influence on the quantity and quality of water flowing from a watershed. An undisturbed watershed with healthy native vegetation in and along waterways and a diversity of habitats on the uplands typically provides good quality water that supports the desirable beneficial uses of the waterways. As the watershed is affected by logging, agriculture, urban development or other disturbances, the water quality in the waterways can become degraded. The percent of land area of the Lower Sprague-Lower Williamson subbasin in various land cover types is shown in Table 10-1.

Table 10-1 Square miles and percent subbasin area of 14 land cover types (Gap Analysis Project (GAP)) occurring in the Lower Sprague-Lower Williamson subbasin (Data Source: Kiilsgaard 1999)

Land Cover Name[1]	GAP Type	Acres	Area (mi^2)	Percent of Subbasin
Ponderosa Pine Dominant Mixed Conifer Forest	40	50,680.0	79.2	13.4%
Lodgepole Pine Forest and Woodland	44	5,039.3	7.9	1.3%
Ponderosa Pine Forest and Woodland	54	54,131.7	84.6	14.3%
Ponderosa Pine-W. Juniper Woodland	58	5,537.7	8.7	1.5%
Ponderosa-Lodgepole Pine on Pumice	59	111,084.3	173.6	29.3%
Western Juniper Woodland	61	5,392.3	8.4	1.4%
Sagebrush Steppe	91	24,786.8	38.7	6.5%
Low-Dwarf Sagebrush	93	27,492.4	43.0	7.2%
Grass-shrub-sapling or Regenerating Young Forest	121	22,466.4	35.1	5.9%
Urban	124	2,471.5	3.9	0.7%
Agriculture	125	41,625.5	65.0	11.0%
Lava Flow	127	375.8	0.6	0.1%
NWI Palustrine Shrubland	201	26,375.9	41.2	7.0%
NWI Palustrine Emergent	203	1,984.6	3.1	0.5%
Total		**379,444.1**	**592.9**	

[1] The area occupied by open water (i.e., rivers, streams, lakes, ponds, reservoirs) is not included in the calculations in this table.

The most prominent type of land use in the Lower Sprague-Lower Williamson subbasin is forestry, with little developed land. Based on this type of prominent land use, it is likely that water quality problems associated with toxic industrial chemicals are of relatively little importance, while problems associated with sediment, turbidity, temperature, and possibly bacteria are likely to be more

important. To the extent that herbicides and pesticides are used in forestry and agriculture operations, these toxic compounds may assume greater importance.
The Total Maximum Daily Load (TMDL) is a tool water quality managers use to address water quality problems. TMDLs provide the framework for restoring impaired waters by establishing the maximum amount of a pollutant that a waterbody can take in without adverse impact to fish, wildlife, recreation, or other beneficial uses. The Sprague River TMDL analysis (ODEQ 2002) identifies forestry, agriculture, transportation, rural residential and urban areas as existing nonpoint sources in the subbasin.

EVALUATION CRITERIA

The evaluation criteria for this Watershed Assessment are based on the Oregon Water Quality Standards for the Upper Klamath Basin (OAR 340-041-0001 to 340-041-0350) and on literature values, where there are no applicable standards (WPN 1999). For example, there are no standards for nutrients (phosphorous and nitrogen). The evaluation criteria are not identical to the water quality standards in that not all seasonal variations are included. The evaluation criteria, listed in Table 10-3, are used as indicators that a possible problem may exist.

The water quality evaluation criteria are applied to the available data by noting how many water quality data points, if any, exceed the criteria. If sufficient data are available, a judgment is made based on the percent exceeded of the criteria, as shown in Table 10-2. If insufficient data or no data are available, this is noted as a data gap to be filled by future monitoring. If any water quality constituent is rated by ODEQ as "moderately impaired" or "impaired" using these criteria, water quality in the stream reach in question is considered impaired for the purposes of the assessment. In the case of the Lower Sprague-Lower Williamson subbasin, such decisions have already been made for some stream segments and some parameters.

Table 10-2 Criteria for evaluating water quality impairment (Data source: WPN 1999)

Percent of Data Exceeding the Criterion	Impairment Category
Less than 15 percent	Not impaired
15 to 50 percent	Moderately impaired
More than 50 percent	Impaired
Insufficient data	Unknown

Table 10-3 Water quality criteria and evaluation indicators (Data source: WPN 1999)

Water Quality Attribute	Evaluation Criteria
Temperature[1]	Core cold-water habitat: The seven-day-average maximum temperature may not exceed 16.0° C (60.8° F);
	Lahontan cutthroat trout or redband trout: The seven-day-average maximum temperature may not exceed 20.0° C (68.0° F);
	Bull trout spawning and juvenile rearing: The seven-day-average maximum temperature may not exceed 12.0° C (53.6 ° F).
Dissolved Oxygen[2]	For water bodies identified as active spawning areas, the following criteria apply during the applicable spawning through fry emergence: (a) The dissolved oxygen may not be less than 11.0 mg/L. (b) However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 milligrams per liter (mg/L) or greater, then the dissolved oxygen criterion is 9.0 mg/L.
	Cold-water aquatic life: The dissolved oxygen may not be less than 8.0 mg/L as an absolute minimum. Where conditions of barometric pressure, altitude and temperature preclude attainment of the 8.0 mg/L, dissolved oxygen may not be less than 90 percent of saturation.
pH[3]	Estuarine and fresh waters: 6.5-9.0
Nutrients	Total phosphorus: 0.022 mg/L
	Total nitrate: 0.38 mg/L
Bacteria[4]	Fresh waters and estuarine waters other than shellfish growing waters: (a) A 30-day log mean of 126 *E. coli* organisms per 100 milliliters, based on a minimum of five samples; (b) No single sample may exceed 406 *E. coli* organisms per 100 milliliters.
Turbidity	2.34 nepholometric turbidity unit (NTU); 50 NTU maximum
Organic Contaminants	Any detectable amount
Metal Contaminants	Arsenic: 0.190 mg/L
	Cadmium: 0.0004 mg/L
	Chromium (hex): 0.011 mg/L
	Copper: 0.0036 mg/L
	Lead: 0.0005 mg/L
	Mercury: 0.000012 mg/L
	Zinc: 0.0327 mg/L

[1] ORS 340-041-0028
[2] ORS 340-041-0016
[3] ORS 340-041-0185
[4] ORS 340-041-0009

WATER QUALITY LIMITED WATER BODIES

Sometimes applying the best available treatment technology to all the point sources in a basin does not bring the stream into compliance with water quality standards. Under this circumstance, if all practicable measures have been taken to improve water quality by controlling discharges, the water body is declared by ODEQ to be "water quality limited" as required by the Clean Water Act, section 303(d). Water quality limited water bodies are placed on the state's "303(d) list." Water bodies on the 303(d) list must be analyzed to determine the total amount of pollutant that can be accommodated by the stream through a TMDL analysis. The load is then allocated to all the dischargers, including nonpoint sources. Dischargers must then take the steps necessary to meet their allocated load, usually by developing water quality management plans. Once a TMDL and waste load allocation is completed, the water bodies to which it applies are removed from the 303(d) list. The water quality limited stream segments in the Lower Sprague-Lower Williamson subbasin are listed in Table 10-4 and illustrated in Map 10-1. These streams do not appear on the 2002 303(d) list, because a TMDL allocation was completed in 2002 (ODEQ 2002).

Most of the stream segments on the list are included because they did not meet the previous water quality standard for temperature for salmonid rearing (17.8^{o} C, 64^{o} F). A new temperature standard has been adopted for waters designated as redband trout habitat (20^{o} C, 68^{o} F) since completion of the Upper Klamath Lake TMDL and Water Quality Management Plan (WQMP) in 2002 (ODEQ 2002) as a result of a better understanding of the temperature tolerance of redband trout.

It should also be mentioned that, in addition to the Upper Klamath Lake WQMP, there has been a state-led process oriented toward addressing agricultural water quality issues. This process is driven by Oregon Senate Bill 1010, and includes the involvement of a Local Advisory Committee made up of interested stakeholders. This Agricultural Water Quality Plan has been included as a component of the overall WQMP and the TMDL. The Upper Klamath Lake WQMP lists unacceptable conditions in the regulatory section (ODEQ 2002). The Oregon Department of Agriculture (ODA) can respond to complaints about landowners whose properties appear to be exhibiting unacceptable conditions. ODA will work with landowners to bring them into compliance, but may also fine landowners who are out of compliance.

Unacceptable conditions in the regulatory section include (ODA 2007):

(1) All landowners or operators conducting activities on lands in agricultural use will comply with the following criteria. A landowner is responsible for only those conditions resulting from activities caused by the landowner. A landowner is not responsible for conditions resulting from actions by another landowner on other lands. A landowner is not responsible for conditions resulting from unusual weather events or other exceptional circumstances that could not have been reasonably anticipated. A landowner is not responsible for natural increases in nutrient or temperature loading. Limited duration activities may be exempt from these conditions subject to prior written approval by the department.
(2) Excessive Sheet and Rill Erosion: Effective January 1, 2007. Combined sheet, rill and wind erosion of soil averaged through a crop rotation period shall not be greater than the soil-loss tolerance value (T).
(3) Nonfunctional Riparian Conditions: Effective January 1, 2007.
(a) Agricultural activities must not create riparian conditions that are downward-trending according to Technical Reference 1737-15, 1998, United States Department of Interior, Bureau of Land

Management (Proper Functioning Condition) guidelines or that degrade stream shading consistent with site capability.
(b) Agricultural activities must not prevent riparian areas rated as non-functional by Proper Functioning Condition Guidelines from improving consistent with site capability.
(c) Exemptions from OAR 603-095-3840 3(a) and (b).
(A) Limited duration agricultural activities such as pump installation or livestock crossings provided they do not compromise achieving the conditions described in 603-095-3840(3)(a) and (b).
(B) Constructed irrigation delivery systems, dikes, borrow pits, drainage ditches, and ponds not hydraulically connected to waters of the State.
(d) This rule is not intended to prohibit riparian grazing where it can be managed to meet water quality standards.

Although the 303(d) list identifies water bodies that are known not to meet current water quality standards, the list is not necessarily a complete indicator of water quality in a particular basin. For many stream segments, there are not enough data to make a determination. In addition, the 303(d) listing is tied to the total amount of monitoring done, which is influenced by the number of special monitoring studies completed by ODEQ. Because special studies are frequently concentrated where water quality degradation is a concern, the list is weighted toward poorer quality waters. Consequently, the ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ. The OWQI is a single number that expresses water quality by integrating measurements of eight water quality variables (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+ nitrate-nitrogen, total phosphorus, total solids, and fecal coliform).

The OWQI for waters above Upper Klamath Lake is based on a site in the Williamson River near the Williamson River Store at river mile (RM) 4.6 (Modoc Point Road). The Williamson River subbasin contributes approximately 50 percent of the inflow to Upper Klamath Lake. Moderately high concentrations of total phosphates and biochemical oxygen demand are present at RM 4.6 on the Williamson River during various seasons. Some of the total phosphates is caused by erosion of soils that are naturally high in phosphorous. The availability of phosphorus allows the production of algae, plankton and aquatic plants. When these organisms die and decompose, they consume oxygen, increasing the biochemical oxygen demand in the water. Phosphorous-driven production from these plants also contributes to elevated pH standards. High pH values have been detected in the Williamson River during the summer season. Water quality at this site in the Williamson River (RM 4.6) is better than at the other sites monitored in the Klamath Basin, all of which are below Upper Klamath Lake. On the average, OWQI scores for the Williamson River site are good in the summer and excellent in the fall, winter and spring, and based on the limited data available, water quality appears to be improving (Mrazik 2005). Data are limited to the one site on the Williamson River, which was sampled from 1996 to 2004. This site appears to be improving, possibly due to reduced levels of nonpoint source pollution, increased education about water quality impacts and watershed restoration efforts (Mrazik 2005).

Table 10-4 Water quality limited water bodies in the Lower Sprague-Lower Williamson subbasin
(Data Source: ODEQ 2007b)

Water Body	Stream Miles	HUC[1] Number	HUC Name	Season	Parameter	Criteria
Williamson River	0 to 94.6	18010201	Williamson	January 1 - May 15	Dissolved Oxygen	Spawning: Not less than 11.0 mg/L or 95% of saturation
Sprague River	0 to 45.7	18010202	Sprague	Year-round (Non-spawning)	Dissolved Oxygen	Cold water: Not less than 8.0 mg/L or 90% of saturation
Sprague River	0 to 79.2	18010202	Sprague	Summer	pH	pH 6.5 to 9.0

[1] HUC = Hydrologic unit code.

WATER QUALITY DATA

Water quality data collected by ODEQ in the Lower Sprague-Lower Williamson subbasin were retrieved from the ODEQ Laboratory Analytical Storage and Retrieval (LASAR) database (ODEQ 2005). Twelve sites in the Lower Sprague-Lower Williamson subbasin have been sampled for water quality by ODEQ. Additional sites have been sampled by the Klamath Tribes, Williamson Watershed Working Group and the Fremont-Winema National Forest. The sites are listed in Table 10-5 and shown on Map 10-1. ODEQ samples were collected in August 1999 and August 2000. Summary information for the constituents that were measured is provided in Table 10-6.

The Natural Resources Department of the Klamath Tribes has an active water quality monitoring program in the Lower Sprague-Lower Williamson subbasin. In addition to detailed temperature monitoring, information is collected on a variety of water quality constituents.

ODEQ, in response to the requirements of the Clean Water Act, has completed a TMDL and WQMP for the Upper Klamath Lake watershed (ODEQ 2002) that incorporates and analyzes much of the data collected in the Lower Sprague-Lower Williamson subbasin.

Table 10-5 Sites in the Lower Sprague-Lower Williamson subbasin sampled for water quality by the Oregon Department of Environmental Quality (ODEQ), U.S. Forest Service (USFS) and Klamath Tribes Natural Resources Department (KNRD)
(Data Sources: KNRD 2006, ODEQ 2007a)

Station Description	Latitude	Longitude	Station ID	Organization
Whiskey Creek	42.4351	-121.3416	SR0200	KNRD
Sprague River at Beatty Gap (Beatty)	42.4478	-121.2366	28152	KNRD
USGS Gage	42.4506	-121.2366	SR0130	KNRD
Sprague River at Godowa Road (Godowa)	42.4604	-121.2699	SR0060	KNRD
Sprague River at Sprague River Road & River Crest Road	42.4620	-121.5003	21535	ODEQ
Sprague River at Klamath County public access at Drews Road	42.4685	-121.3821	21561	ODEQ
Sprague River at Sprague River Road	42.4772	-121.5222	11274	ODEQ
Sprague River at Rabe Ranch off Sprague River Road	42.4785	-121.5759	21536	ODEQ
North Fork Trout Creek	42.4847	-121.6272	26566	USFS
Trout Creek at Forest Service Gage	42.4864	-121.6206	23608	ODEQ
Trout Creek	42.4873	-121.6218	SR0100	KNRD
Williamson River at Store (Bridge Crossing on Modoc Point Road)	42.5147	121.9169	WRST	KNRD
Five Mile Creek	42.5431	-121.1203	SR0120	KNRD
Sprague River at Lone Pine (Lone Pine)	42.5505	-121.6176	SR0080	KNRD
Sprague River at Saddle Mountain Pit Road (FS 58)	42.5513	-121.6188	21537	ODEQ
Sprague River at Sprague River Road Bridge #858-02	42.5650	-121.6819	21566	ODEQ
Sprague River	42.5656	-121.6815	25388	ODEQ
Sprague River 0.25 miles upstream of Chiloquin	42.5677	-121.8648	10773	ODEQ
Sprague at Kirchers Bridge (Kirchers)	42.5713	121.8722	SRKB	KNRD
Sprague River at Power Plant (Power Plant)	42.5846	-121.8419	SR0090	KNRD
Sprague River east of Chiloquin	42.5928	-121.8213	11481	ODEQ
Sprague River Hatchery (Hatchery)	42.5990	-121.8200		KNRD
Sprague River at Sprague River Road and Williamson Road	42.6015	-121.7771	21538	ODEQ

Table 10-6 Summary of water quality data collected by ODEQ in the Lower Sprague-Lower Williamson subbasin in August 1999 and August 2000
(Data Source: ODEQ 2007a)

Constituent	No. of Observations	Minimum	Maximum	Median	Mean
Alkalinity as Calcium Carbonate (mg/L)	10	56	65	58	59.60
Ammonia as Nitrogen (mg/L)	38	<0.02	0.060	0.015	0.02
Biochemical Oxygen Demand (mg/L)	37	0.300	2.900	0.700	0.80
lculated Dissolved Hardness as Calcium Carbonate (mg/L)	1	26	26	26	26.00
Chemical Oxygen Demand (mg/L)	38	6	13	9	8.74
Chlorophyll *a* (µg/L)	31	0.1	1.5	0.6	0.68
Dissolved Aluminum (mg/L)	1	0.299	0.299	0.299	0.30
Dissolved Calcium (mg/L)	1	5.86	5.86	5.86	5.86
Dissolved Chloride (mg/L)	27	0.9	1.8	1.5	1.47
Dissolved Iron (mg/L)	1	0.2	0.2	0.2	0.20
Dissolved Lanthanum (mg/L)	1	0.001	0.001	0.001	0.00
Dissolved Lithium (mg/L)	1	0.001	0.001	0.001	0.00
Dissolved Magnesium (mg/L)	1	2.77	2.77	2.77	2.77
Dissolved Manganese (mg/L)	1	0.012	0.012	0.012	0.01
Dissolved Orthophosphate as Phosphorus (mg/L)	38	0.020	0.132	0.039	0.04
Dissolved Potassium (mg/L)	1	1.49	1.49	1.49	1.49
Dissolved Sodium (mg/L)	1	4.91	4.91	4.91	4.91
Dissolved Sulfate (mg/L)	27	0.44	1.33	0.66	0.70
Field Alkalinity as Calcium Carbonate (mg/L)	27	34	66	59	58.59
Field Conductivity (µmhos/cm)	37	78	142	127	127.38
Field Dissolved Oxygen (mg/L)	38	5.8	10.9	8.8	8.66
Field pH (standard units)	38	7.7	9.3	8.8	8.75
Field Temperature (°C)	38	11.8	23.3	19.7	19.48
Field Turbidity (NTU)	22	1.3	10.0	3.1	3.24
Nitrate/Nitrite as Nitrogen (mg/L)	38	<0.005	0.018	0.003	0.00
Percent Saturation Field Dissolved Oxygen (%)	12	71	139	106	102.67
Pheophytin *a* (µg/L)	31	0.100	1.600	0.650	0.72
Total Calcium (mg/L)	1	5.86	5.86	5.86	5.86
Total Dissolved Solids (mg/L)	27	83	110	98	98.78
Total Kjeldahl Nitrogen (mg/L)	38	<0.2	0.4	0.3	0.26
Total Organic Carbon (mg/L)	38	2	5	3	3.24
Total Phosphorus (mg/L)	38	0.04	0.10	0.07	0.07
Total Solids (mg/L)	38	89	120	110	107.63
Total Suspended Solids (mg/L)	38	<1.0	6	1	1.52

Table 10-7 Sites in the Lower Sprague-Lower Williamson subbasin with more than 10 measurements for various water quality constituents (Data Source: ODEQ 2007a, KNRD 2006)

Site Name	Number of Samples
Sprague River at Power Plant	150
Sprague River at Godowa Road	146
Sprague River at Lone Pine	137
Sprague River at Kirchers Bridge	282
Williamson River at Store	280

WATER QUALITY CONSTITUENTS

Temperature

Many of the stream segments in the Lower Sprague-Lower Williamson subbasin are water quality limited for temperature based on the 1998 303(d) list (Map 10-1), although they do not appear on the 2002 303(d) list. They were removed following completion of the Upper Klamath Lake TMDL. In addition, a new water temperature standard that recognizes the special adaptation of redband trout and permits a higher temperature was adopted for waters supporting redband trout use[2] since the completion of the TMDL.

It is recognized that while other water quality parameters are also out of compliance with the standards, temperature is the primary limiting factor. If temperature is brought into compliance, dissolved oxygen and pH would most likely also fall within the standards, because dissolved oxygen decreases with increases in temperature. The pH levels are also correlated with temperature.

Riparian area management and revegetation measures are proposed in the Upper Klamath Lake TMDL and WQMP (ODEQ 2002) to bring these areas into compliance with relevant criteria. Since the WQMP was published, there have been many accomplishments with regard to implementing the recommendations of the plan.

Dissolved Oxygen

Information for evaluation of dissolved oxygen in stream segments in the Lower Sprague-Lower Williamson subbasin comes primarily from data collected by the Klamath Tribes in 2001 through 2005, and from data collected by ODEQ on three days in August 1999 and August 2000. Much of the information available is in raw data format and not compiled for easy comparison of these reaches.

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[2] OAR 340-41-0028: "Temperature.
(4) Biologically Based Numeric Criteria. Unless superseded by the natural conditions criteria described in section (8) of this rule, or by subsequently adopted site-specific criteria approved by EPA, the temperature criteria for State waters supporting salmonid fishes are as follows:
(e) The seven-day-average maximum temperature of a stream identified as having Lahontan cutthroat trout or redband trout use on subbasin maps and tables set out in OAR 340-041-1010 to OAR 340-041-0340:…Figure 180A,…may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit);…."

pH

Measurements for pH were taken at the same time as those for dissolved oxygen. Values measured for pH are presented in Figure 10-1. The Sprague River has been listed as water quality limited for pH and was included in the Upper Klamath Basin TMDL.

Nutrients

Dissolved nutrients, especially nitrogen and phosphorus, can adversely influence water quality indirectly by promoting algae growth. Excessive algae growth results in increases in pH, and when algal blooms die, there are reductions in dissolved oxygen that may fall outside the relevant criteria.

Phosphorus

Data for total phosphorus are presented in Figure 10-2. All of the measured values for total phosphorus exceed the U.S. Environmental Protection Agency (EPA) criterion value of 0.022 mg/L. The Lower Sprague-Lower Williamson subbasin is considered impaired with respect to phosphorus concentration. There are no point source discharges in the subbasin that might contribute phosphorus to subbasin streams, so the elevated concentrations are the result of nonpoint and natural sources. High phosphorus values are not localized to a particular subbasin within the assessment area.

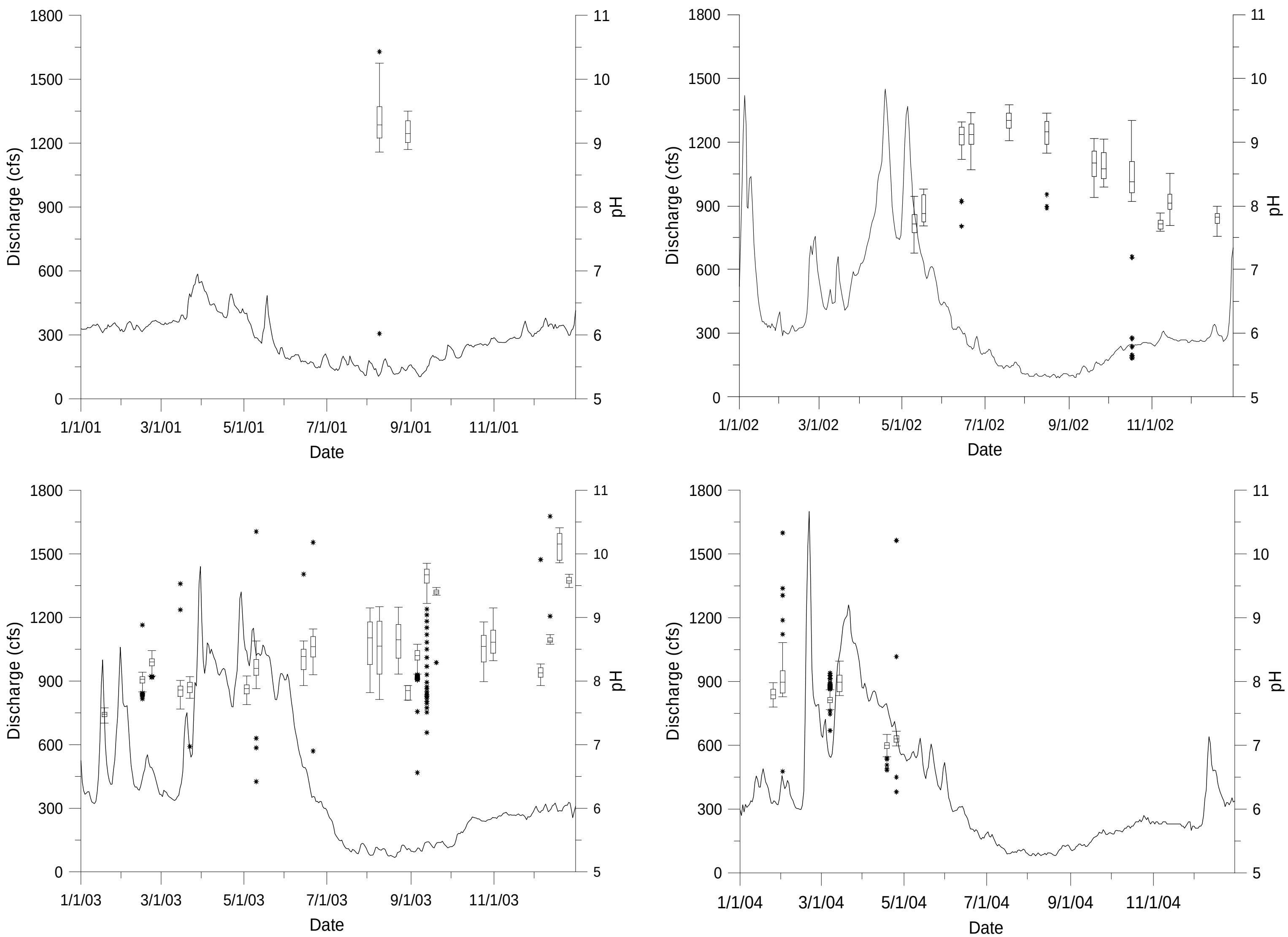

Figure 10-1 pH values measured by the Klamath Tribes Natural Resources Department in the Lower Sprague-Lower Williamson subbasin near the hatchery in 2001 through 2004 with relationship to discharge
(Data Sources: KNRD 2006, USGS 2007)

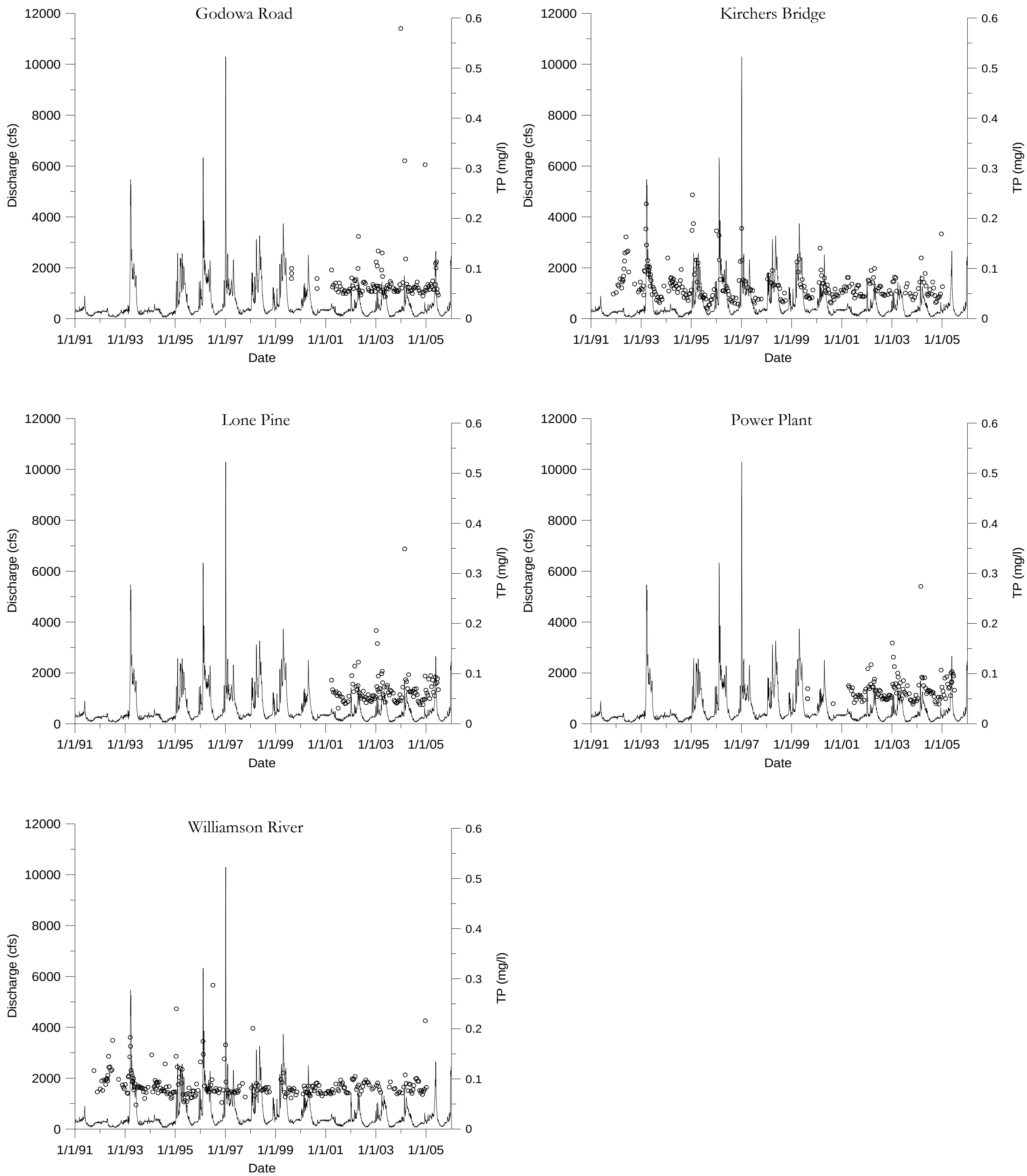

Figure 10-2 Total phosphorus (TP) values measured by the Klamath Tribes Natural Resources Department at several sites in the Lower Sprague-Lower Williamson subbasin in 1991 through 2005 with relationship to discharge
(Data Sources: KNRD 2006, USGS 2007)

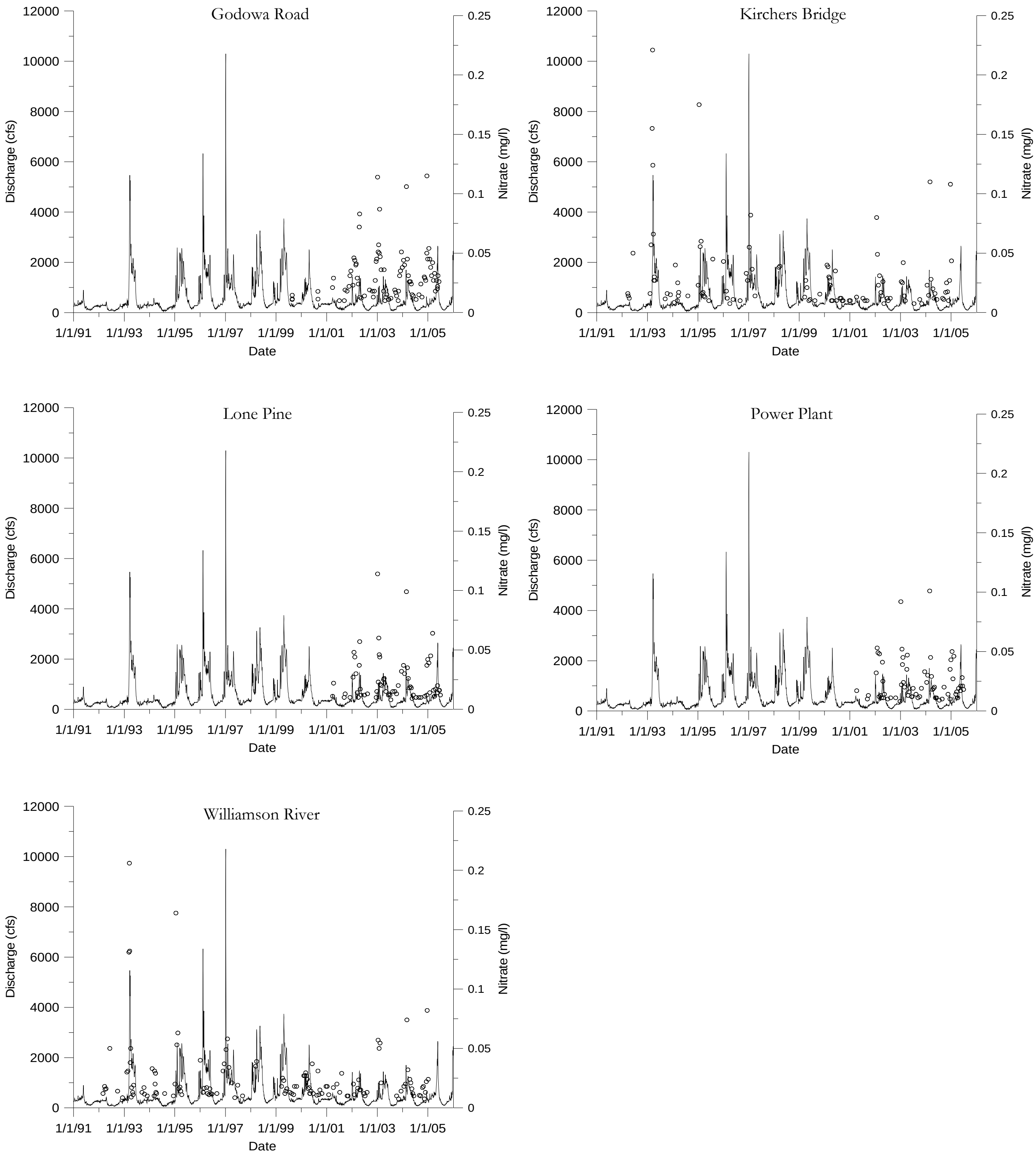

Figure 10-3. Nitrate-nitrogen values measured by the Klamath Tribes Natural Resources Department at several sites in the Lower Sprague-Lower Williamson subbasin in 1991 through 2005 with relationship to discharge.
(Data Sources: KNRD 2006, USGS 2007)

Nitrogen

Nitrate-nitrogen data collected in the Upper Sprague River subbasin are presented in Figure 10-3. Nitrogen functions similarly to phosphorous in its effects on algal blooms. However, in this watershed, phosphorous is thought to be more influential in driving the algal blooms. Ammonia toxicity is an additional concern to fish, particularly where high temperatures and pH exist and whether or not samples have exceeded the criteria. EPA criteria do not have one specific concentration for nitrogen but are based on total ammonia concentration for given water temperature and pH.

Bacteria

Bacterial contamination of water from many sources (including mammalian or avian sources, livestock feeding operations or improperly functioning sewage treatment systems,) can cause the spread of disease through contact recreation or ingestion of the water itself. Bacteria of the coliform group (either *E. coli* or fecal coliform bacteria) are used as an indicator of possible fecal bacterial contamination. A limited number of samples for *E. coli* were collected during the summer in 1999 and 2000 in the Lower Sprague River subbasin. The available data are summarized in Table 10-8.

Table 10-8 Results of bacterial samples analyzed for *E. coli* from the Lower Sprague River subbasin in 1999 and 2000
(Data Source: ODEQ 2007a)

Date	08/17/99	08/18/99	08/22/00	08/23/00
Sprague River near Chiloquin	<2			
Sprague River at Godowa Springs Road	66	52	40	
Sprague River at Drews Road		74		
Sprague River at Sprague River Road and River Crest Road		86		
Sprague River at Sprague River Road and Williamson Road				56

Turbidity

Turbidity is a measure of the clarity of the water. High turbidity is associated with high suspended solids and can be an indicator of erosion in the watershed. At high levels, turbidity can have negative effects, such as impairing the ability of salmonid fish to see their prey. A limited number of turbidity measurements were made in the Lower Sprague River subbasin in 1999 and 2000. They are summarized in Table 10-9. No value exceeded the evaluation criterion of 50 NTU; however, most of the measurements were made during the summer when turbidity values might be expected to be low. Few, if any, measurements were made during high flow periods. The available data are insufficient to determine the status of streams in the Lower Sprague-Lower Williamson subbasin with respect to turbidity.

Table 10-9 Turbidity measurements (NTU) and discharge (cubic feet per second (cfs)) in the Lower Sprague River subbasin (Data Source: ODEQ 2007a)

Station Description	Date	Turbidity (NTU)	Discharge (cfs)
Sprague River at Sprague River Road	02/20/90	7.0	260
Sprague River at Saddle Mountain Pit Road (FS 58)	08/19/99	2.5	289
Sprague River at Sprague River Road Bridge #858-02	08/19/99	2.0	289
Sprague River 0.25 miles upstream of Chiloquin	08/19/99	2.0	289
Sprague River at Chiloquin Ridge Road Power Station	08/19/99	2.0	289
Sprague River east of Chiloquin	08/25/80	3.0	159
Sprague River east of Chiloquin	05/19/80	10.0	1,020
Sprague River east of Chiloquin	02/25/78	30.0	834
Sprague River east of Chiloquin	02/25/80	30.0	1,640
Sprague River at Sprague River Road and Williamson Road	08/19/99	2.2	289

Contaminants

Synthetic organic compounds, pesticides and metals can be toxic to aquatic organisms, and can pose potential threats to public health. The presence of such contaminants in the water may suggest the presence of sources of pollution that could have an adverse effect on the stream ecosystem.

There were no data available to assess water quality conditions in the Lower Sprague-Lower Williamson subbasin with respect to contaminants. However, local knowledge recognizes illegal dumping from methamphetamine laboratories and other activities (B. Hyde pers. comm., September 2006).

SUMMARY OF WATER QUALITY CONCERNS

At the screening level of this assessment, water quality in the major streams of the Lower Sprague-Lower Williamson subbasin would be considered impaired because of the frequency that values exceeded the evaluation criteria for temperature, pH, phosphorus and possibly dissolved oxygen. Insufficient data are available to determine the status of streams with respect to inorganic or organic contaminants. These water quality impairments (e.g., temperature, pH and dissolved oxygen) have been addressed in the Upper Klamath Lake Drainage TMDL and WQMP (ODEQ 2002). Concerns have been raised, however, that the proposals of the WQMP will not be adequate to address the water quality impairment issues (NAS 2003). There are many sources of water quality impairment related to human activities in the subbasin. These include current activities associated with agriculture, forestry, recreation, illegal dumping and urban development. In particular, however, water quality is affected by a long-term legacy of land use and water use that have developed over more than a century.

The relative importance of the various water quality stresses is not completely clear, nor is the understanding of issues such as phosphorous loading. The Upper Klamath Lake TMDL attempts to describe the wetland drainage and nutrient export from drained wetlands and agricultural pumps (Snyder and Morace 1997), as well as Williamson/Sprague River flows as related to phosphorous export. McCormick and Campbell (2007) provide best management practices that may be effective to address water quality issues in the Upper Klamath Basin, as well as causes of nutrient loading above Upper Klamath Lake. It was found that increased water yields and runoff rates in the Williamson and Sprague river drainages have been documented in the 1951 to 1996 period, which are independent of climatic conditions (Riseley and Laenen 1999). The increase in water yield is likely caused by channelization, wetland/riparian area conversions and reductions in evapotranspiration in the watershed. Increased water yields are associated with increased erosion and particulate total phosphorus transport. These increased water yields are likely the result of human land use and may account for 18 percent of the external phosphorus loading to the lake (ODEQ 2002). It is likely that additional data, obtained through a carefully designed water quality monitoring program, will be required in order to adequately address the causes of water quality impairment throughout the subbasin.

In many western watersheds, water quality problems are linked to limited water quantity, inadequate riparian vegetation along some reaches, associated soil erosion, and loss or degradation of wetland habitats. Each of these issues can affect water quality, especially temperature, in a variety of ways depending on site-specific conditions. It is important that any future research help confirm whether or not this is the case within the assessment area.

Water quality limited streams are found in every watershed throughout the assessment area (Map 10-1). Water quality limitations are particularly prevalent along the lower mainstem river reaches. In virtually all cases, water quality limitation is associated with water temperature. Summer water temperatures are too high in many streams to support healthy fish populations.

Stream temperature is vitally important to the health and well-being of cold-water fish species. It influences the metabolism, growth rates, availability of food, predator-prey interactions, disease-host relationships, and timing of life history events of fish and other aquatic organisms (Spence et al. 1996). Temperature requirements vary by species, season and life stage, and conditions most frequently approach harmful levels in the late summer when air temperatures are high and stream flows are low. High water temperature also contributes to reduced dissolved oxygen levels, which in turn can affect the ability of fish to respire.

Many studies have concluded that stream temperatures increase in response to timber harvesting, especially when vegetation is removed up to the edge of the stream (Levno and Rothacher 1967, Meehan 1970, Feller 1981, Hewlett and Fortson 1982, Holtby 1988, ODF and ODFW 2002). While the direct applicability of these studies to the assessment area is variable, allowing riparian vegetation to remain near the stream has been shown to reduce the effects of harvesting on stream temperature (Brazier and Brown 1973, Kappel and DeWalle 1975, Lynch et al. 1985, Amaranthus et al. 1989, ODF and ODFW 2002). Consequently, forest management policies now require the maintenance of a riparian vegetation buffer along streams on private, state and federal lands.

Riparian corridors in forested areas develop a microclimate characterized by cooler air temperatures and higher relative humidity compared to unvegetated streamside areas. Near-stream ground temperatures can be an even greater source of heat to the stream, because the heat conductivity of soil is typically 500 to 3,500 times greater than that of air (Halliday and Resnick 1988).

In addition to the absence of stream shading, there are other factors (some of which are related to stream shading) that might be responsible for the observed high temperature of certain streams within the subbasin. They include:

- prevailing watershed aspect (south- and west-facing are often warmer than north- and east-facing);
- prevalence and temperature of seeps, springs, groundwater and tailwater inflow;
- amount of exposed rock in the stream channel (which can effectively absorb solar heat);
- reduced summer flows; and
- prevalence of deep pools.

A properly functioning riparian-wetland area with a well-developed floodplain and deeply rooted riparian plants captures and stores water during the wet season, slowly releasing cool water during the dry summer months. Many lowland valley areas and wet meadows in the Lower Sprague and Lower Williamson rivers probably were never heavily shaded but are characterized by well-developed floodplains and a variety of marshy and swampy areas that functioned to maintain water quality conditions, including temperature. This is a central issue in the assessment area, because many regulatory indicators of riparian health and water quality standards focus on the presence/absence of woody riparian vegetation. This topic should be a focus of future research and monitoring.

A relatively unique issue pertinent to the assessment area is the influence of groundwater pumping on water temperatures. Groundwater pumped at 59° F enters surface flows as tailwater and may lower temperatures locally. Future monitoring and research should be aimed at confirming the extent to which this does occur.

Water temperature and water quantity are closely linked. A reduction in flow during low-flow periods contributes to higher water temperature. Nevertheless, even if some reaches have elevated solar radiation and stream temperature levels, an adequate supply of deep pools can provide cold-water refugia that allow fish to avoid adverse temperature conditions. Temperature differences between the stream surface and stream bottom can be substantial in deep pools (Matthews et al. 1994, Nielsen et al. 1994). Deep pools are less prevalent today than in the past, mainly because of changes in the flow dynamics within stream channels. The supply of gravel in the streambed can also serve to moderate stream temperature. A large amount of water flows through gravel deposits, sheltered from the warming rays of the sun. Where gravel deposits are diminished or filled with fine sediments, such deep inter-gravel stream flow is reduced.

There are a number of large springs in the subbasin that discharge cool water to the streams and provide thermal refugia for fish. Alterations of the stream channel through ditching or diking can separate the springs from the stream, thereby removing vital habitat.

There are also a number of warm springs both near and within stream channels based on Forward-Looking Infrared Radiometry (FLIR) data from ODEQ. These springs may have measurable effect on water temperatures within the assessment area.

It is not clear whether or not summer and early fall stream temperatures in many streams within the Lower Sprague-Lower Williamson subbasin were ever as low as the 12° C (53.6° F) spawning and rearing evaluation criterion for bull trout, or even the core cold-water habitat criterion for salmonid fish of 16° C (60.8° F). Nevertheless, efforts to reduce stream temperatures subbasin-wide would be expected to have positive effects on fish habitat quality.

DATA, METHODS AND LIMITATIONS

The maps, figures and tables for this chapter were prepared using raw data obtained from the ODEQ LASAR database and from data provided by the KNRD on CD-ROM. The ODEQ database includes data collected by the Klamath Tribes, the Winema-Fremont National Forest, ODEQ and the Williamson River Watershed Council. The KNRD CD-ROM provided additional data from the Klamath Tribes not included in the LASAR database.

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